PROCEEDINGS

OF THE

Second Meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India

Held at Lahore from the 6th to 9th December, 1937 with Appendices.

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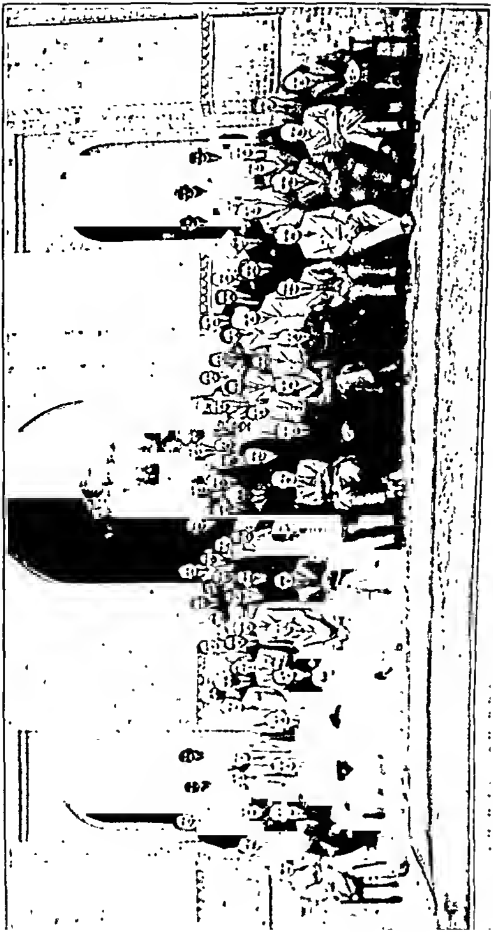

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The Second Meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry.

INTRODUCTORY.

The Second Meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India was held at Lahore on the 6th December 1937, and following days under the presidency of His Excellency Sir Herbert Emerson, Governor of the Punjab

Members

The following members were present :—

1. Sir Bryce Burt (*Chairman*).
2. Dr. W Burns.
3. Col. Sir Arthur Olver.
4. Mr R G. Allan.
5. Mr. N. S Apte.
6. Rao Sahib D V. Bal
7. Dr J K. Basu.
8. Mr J. H. Bedford.
9. Mr. S H. Bigsby.
10. Mr. N. G. Charley.
11. Mr R. L. Chaturvedi.
12. Dr J. K Dubey.
13. Khan Bahadur M. Fateh-ud-Din.
14. Mr. M R. Fotedar
15. Sardar Harchand Singh.
16. Mr. P. V. Isaac.
17. Mr. S. S Iyer.
18. Mr. W. J. Jenkins.
19. Professor L. S. S. Kumar.
20. Dr. P. E. Lander.
21. Dr. V. N. Likhite.

4. Dr. Frank Crowther.
5. Dr. Dalip Singh.
6. Sardar Darshan Singh.
7. Mr. Ihsanullah.
8. Rai Sahib Jai Chand Luthra.
9. Mr. D. P. Johnstone.
10. Rai Sahib Kalidas Swahney.
11. Sardar Kartar Singh.
12. Dr. P. G. Krishna.
13. Mr. M. Nabi.
14. Major G. V A. Prideaux.
15. Dr. A. N. Puri.
16. Mr. R. G. Sadik.
17. Mr. A. M. Thomson.

22. Mr. T. R. Low.
23. Mr. K. R. Narayana Iyer.
24. Lt.-Col. C. A. MacLean.
25. Professor P. C. Mahalanobis.
26. Mr. Mobindra Bahadur.
27. Mr. A. Majid.
28. Dr. B. K. Mukherjee.
29. Mr. Nizam-ud-Din Hyder.
30. Dr. B. P. Pal.
31. Mr. G. B. Pal.
32. Dr. H. S. Pruthi.
33. Dr. G. W. Padwick.
34. Mr. P. H. Rama Reddi.
35. Rao Bahadur M. R. Ramaswami Sivan.
36. Dr. L. A. Ramdas.
37. Dr. R. D. Rege.
38. Mr. P. B. Richards.
39. Mr. M. R. Richardson.
40. Mr. W. Roberts.
41. Mr. T. S. Sabnis.
42. Mr. Wynne Sayer.
43. Mr. D. R. Sethi.
44. Mr. H. R. Stewart.
45. Rao Sahib K. I. Thadani.
46. Sardar Sahib Sardar Ujjal Singh.
47. Dr. B. N. Uppal.
48. Rao Bahadur B. Viswanath.
49. Mr. R. Watson (Representative of Burma).
50. Mr. N. C. Mehta, Secretary, I. C. A. R.
51. Rai Bahadur R. L. Sethi (*Rapporteur*).

VISITORS.

The following attended as visitors :—

1. Khan Bahadur M. Afzal Husain.
2. Mr. N. K. Bose.
3. Mr. H. C. Choudhuri.

4. Dr. Frank Crowther.
5. Dr. Dalip Singh.
6. Sardar Darshan Singh.
7. Mr. Ihsanullah.
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9. Mr. D. P. Johnstone.
10. Rai Sahib Kalidas Swahney.
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PROCEEDINGS.

First day.

In requesting His Excellency the Governor of the Punjab to open the proceedings of the Board, Sir Bryce Burt (*Chairman*) spoke as follows:—

"Your Excellency,

May I, in the first place, on behalf of the Board, express our great appreciation of your great kindness, despite your numerous engagements, in coming here this morning to open the second meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India. It is also my great privilege to thank your Excellency's Government for their invitation to hold this meeting at Lahore and for the hospitable arrangements which have been made for members of the Board to see some of the work of the Punjab Agricultural Department at Lyallpur at the close of the week. These are but further tokens of the great interest which Your Excellency is known to take in all matters which affect the welfare of the rural population of this great province and of the importance which the Punjab Government attaches to the work of its Agricultural Department May I also take this opportunity of welcoming, on behalf of the Board, those Honourable Ministers of the Punjab Government who have found time, despite their numerous engagements, to support us by their presence here this morning.

"For a special reason, it is particularly appropriate that the first meeting of the Crops and Soils Wing outside Delhi should be held in the Punjab The Board of Agriculture and Animal Husbandry is the lineal descendant of the original Board of Agriculture in India which created the sound precedent of meeting alternately at Pusa then the headquarters of the Imperial Department of Agriculture and in a Province or State. At the first meeting of the Board of Agriculture, the Punjab was represented, amongst others, by Mr. Milligan, who subsequently, as Agricultural Adviser to the Government of India, presided over two memorable meetings of the Board. Mr. Milligan was one of the early pioneers in the application of scientific methods to the solution of Indian agricultural problems and his early work in the Punjab stands to-day as an example to his successors. Indian Agriculture in general

PROGRAMME.

SUBJECTS DISCUSSED.

I. A review of soil survey work in India up to date, with suggestions for the future.

II. A review of the theory and practice of manuring in India, with suggestions for the future:

(a) with reference to farmyard manure and compost,

(b) with reference to green manuring,

(c) *with reference to manuring with artificial manures.*

III. A review of work on the improvement of bullock-drawn implements, with suggestions for the future.

IV. A review of plant breeding in India, with suggestions for the future.

V. A review of the work done on water requirements of crops, with suggestions for the future.

VI. A review of work done on crop protection, with suggestions for the future, with reference to protection from (a) wild animals, (b) insects, (c) fungi, (d) parasitic flowering plants, and (e) effects of climate.

VII. A review of the present position regarding agricultural statistics (in the sense of collection and publication of data) and forecasting, with suggestions for the future

VIII. A review of the application of statistical theory to experimental methods in India so far as agricultural investigation is concerned

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owes much to Mr. Milligan's work, first in this great province and subsequently as Imperial Agriculturist and Agricultural Adviser to the Government of India.

"This is the first occasion on which I have had the honour of presiding over the Crop Production Section of the Board and it is a great personal pleasure that its meeting is taking place at Lahore. Though I have not had the advantage of serving in this province, I have, in various capacities, had many opportunities of appreciating the co-operation which the Imperial Council of Agricultural Research and the Indian Central Cotton Committee have received from the Punjab in their efforts to do something for the improvement of Indian Agriculture.

"It is now my privilege to ask your Excellency to open the proceedings of the Board."

Speech made by His Excellency Sir Herbert Emerson, Governor of the Punjab, at the Opening of the Deliberations of the All-India Board of Agriculture on Monday, the 6th December, 1937.

"Mr. Chairman and Gentlemen,

It is a great pleasure to me to welcome to the Punjab officers from all provinces of India who have done and are doing so much for the millions in this country dependent on the soil. The gathering to-day consists of men who each in his own field has done something, and often a great deal, for the direct benefit of the cultivator, and I can conceive of no more stimulating work. Whether the functions are advisory, administrative, research or executive, their aim is the same, and that aim is to add to the production of the soil. For many years I have taken a close interest in the labours and results of agricultural workers and I yield to no one in appreciating their importance. Important as their work has always been, it is yearly growing in urgency. The population of India is rapidly growing, and, in the absence of unforeseen calamities, the increase must be cumulative. In the Punjab the population is increasing annually at the rate of nearly half a million souls, and a similar phenomenon is to be found in every other province. Much as conditions of soil and cropping and standards of living may differ from one part of India to another, the vital problem is the same, namely, how to raise the standard of life of a population already huge and to the increase of which there is no visible limit. On the one hand, the resources of science are being applied to the prevention and cure of disease and to the creation of more healthy conditions in our towns and villages. On the other hand, the success which science achieves in this direction will be frustrated, if means are not found to raise for an ever-increasing population the low level of comfort which now obtains. Indeed the greater the success which medical science can record in this country, the greater will be the demand placed on agricultural science. For this, if for no other reason no bounds can be set to the labours of the research or field worker on the agricultural side. We can foresee no time when the services of these workers can be dispensed with, without incalculable loss to India.

"You gentlemen are concerned with crops and soils—subjects which may at first sight appear to be confined in scope. But a moment's reflection will at once show the enormous

ground they cover. It is not merely a question of the great variety of crops or the enormous variety of soils which are found in India. Each has to be correlated with the other, and for every crop, as for every kind of soil, there is a large number of problems to be solved many of which have little bearing on the other. The agenda for your meeting does not pretend to cover the whole field, but the subjects which are to come under discussion, are sufficiently comprehensive to indicate the diversity and importance of the problems with which you have to deal. You are concerned at this conference with soil surveys, with the theory and practice of manuring, with the improvement of agricultural implements, with questions of plant breeding, with the water requirements of different crops, with their protection against insect and other pests, and lastly with the different aspects of agricultural statistics. If you were to deal exhaustively with the whole of this agenda, limited as it is, you would require as many months for your business as you have allotted days. It would be impertinent for me to express to a body of experts any opinion on most of these subjects, but I may perhaps be allowed to make a few observations about one or two matters, which have come under my notice as an administrator. I have just said that I can see no limit to agricultural research in India, and I have no doubt that the field worker is sometimes impatient because the scientist does not produce at once practical and simple remedies for the many ills which afflict agriculture. On the other hand, it has always seemed to me that the research worker has a more legitimate grievance in that, for one reason or another, the results of his work have not been applied with the rapidity or on the scale which their value demands. There is a big lag between scientific discovery and its practical application, and it is no doubt in recognition of this fact that Sir John Russell, than whom there is no greater authority, has declared that the great need now is for the full use of existing knowledge rather than the accumulation of more knowledge; for work on the cultivators' fields rather than in the laboratory. A very simple illustration may be given of this truth. In the Punjab our staple crops are wheat and cotton. For years we have known that certain varieties produced by the Agriculture Department give higher yields and sometimes higher prices than those produced by the ordinary cultivator. We also know that for a particular crop, say, wheat, different varieties are more suitable than others for various soils. I would indeed go so far as to say that there is hardly a wheat-growing soil in the

Punjab for which a type cannot be recommended better than that sown before the Agricultural Department came into existence. This being so, commonsense and the common good demand that our aim should be to see that every field produces the variety of wheat that is best suited to it. None the less, until a few years ago it was left mainly to the very small body of agricultural officers to advertise and to apply discoveries, which, measured in money, represented the annual addition of crores of rupees to the wealth of the province As I have often said, a business firm with a marketable commodity of this character would use every possible agency to ensure its general adoption. The obligation resting on Government to do so is still greater. During the past few years the Punjab Government has done something towards mobilizing its forces by bringing into the field the servants of other departments, and especially its revenue officers, to preach the gospel of better seed. The result has been most encouraging. While in 1932-33 the provision made in the Agricultural Department's budget for transactions in improved seed was two lakhs only, the amount allotted in the coming year is eleven and-a-half lakhs. In fact the demand for seed has almost outstripped the supply. But we are still far from the goal which I have mentioned, namely the phenomenon of each field being sown with the type best suited to it Only a few days ago I was talking to a gathering of a hundred villagers or so I asked them what wheat they used and they told me that they used the *desi* variety. I asked why, and they gave the usual answer that they were too poor to use anything else. Too poor—when from a single acre in a single harvest they could obtain an additional return of from three to six rupees by spending four annas more at sowing time. The zaildar of the tract was present and I asked him what he used He gave me the numbers of three different types which he used on different soils, and to my question he replied that in every case the yield was much in excess of the ordinary variety. Here was a simple example of a non-official agent, who, if properly used, could do an enormous amount of practical propaganda. The question of good seed is indeed a matter which closely concerns every land-owner in the province and especially those whose land is tilled by their tenants. We hear a great deal nowadays of bad landlords and although I believe that in the Punjab there are comparatively few that come within this category, none the less there are many who still do not realize the necessity of doing everything they can for their tenants.

fifty-nine per cent. of the experiments had given significant increase and in cases where artificial fertilisers had been used sixty-two per cent. of the experiments had given significant results. It would be observed that these experiments were not strictly comparable. They gave information of a bulk of experiments conducted in several parts of the country with several crops and in different seasons and in different years. There was not very much experimental evidence on comparative tests carried out, except for Burma where manurial work was done for a period of five years and subsequently residual effects were measured in succeeding five years. It would be observed that the increases in yields due to fertiliser treatment had been distinctly greater and higher for direct manuring in the case of organic manures and better than those of artificial manures. These experiments were carried out by Hendry in Burma between 1928 and 1936. He had selected these experiments particularly to show that there were a set of experiments in which there was no risk of complications arising due to moisture being a limiting factor. He further explained that in his note (Appendix II, page 201), he had shown how experiments elsewhere conform to those observations that could be deduced from the experiments carried out in Burma thus clearly pointing the beneficial value generally of organic manures as compared with inorganic fertilisers. He had also shown how moisture and water-supply could be a most powerful limiting factor in manurial experiments. At the bottom of the page he had shown comparative experiments. reported under fairly adequate moisture conditions and under precarious moisture conditions where rainfall was 19" and that too unevenly distributed. In these conditions concentrated manures —organic or inorganic—did more harm than good A general review of the experiments showed that the presence of adequate supplies of organic matter in the soil facilitated the assimilation of nutrients added to the soils in the form of fertilisers. The problem narrowed itself down to find out methods of using fertilisers on adequate dosage of organic manures. He had shown in his note (Appendix II, page 203) how the results of such experiments in which a judicious combination of organic manures and inorganic fertilisers was used led to the highest gross yield. In regard to the comparative study of nutrition of the plant by organic manures and artificial fertilisers, organic manures like oil-cakes produced better conditions of tilth in the soil, but had to undergo decomposition in the soil before they became available. This meant that the

products of decomposition were made available to the plant steadily and gradually and therefore the plant was in a position to absorb them. On the other hand, in the case of inorganic fertilisers the nutrition available was almost in a rush; the plant therefore was not able to utilise it to the best advantage and therefore its method of growth and possibly of development got altered. The next problem for consideration was to take stock of manurial resources in this country. Attention would naturally first turn to farmyard manure. The destruction of farmyard manure had been mentioned by His Excellency the Governor of the Punjab that morning, but even if it was conserved the speaker's calculations showed that we would be in a position to find only about 2/5th of the normal supply required for applying farmyard manure to all the cultivated soils of the country The next best course was to direct our attention to the production of composts Composts work had been in progress at several centres for the last ten years Several methods had been developed but so far none of the methods had reached such a simple form which could be copied by the small cultivator A good deal of work remained to be done

Green manures were generally of considerable benefit to the soil provided the conditions for growing the green manure crop and the conditions in the soil particularly of moisture supply were satisfactory for the decomposition of the green manure. From experience it was known that it was not always possible to grow green manure in every province. In certain provinces cash crops and industrial crops had to be sacrificed for the purpose of growing green manure crop and in certain places the growing of a green manure crop did not pay. In the heavy deltaic paddy soils, green manuring did distinct harm to the soil Also when the soil is summer-ploughed, the land became loose and the subsequent crop grown was considerably interfered with He said that he had known several instances in which such growing of green manure absolutely inhibited subsequent crop growing and it took nearly two to three years for the land to recover for bearing a good crop. He referred to the subject of indigo which in former days was cultivated as a green manure crop. The indigo brought ready money to the farmer and the "seeth" after fermenting formed an excellent manure for the soil besides the nitrogen fixed by the indigo plant itself.

Rao Bahadur Viswanath referred to the distribution of the available manure by the cultivator and said that a greater portion was put in the more fertile land required to grow cash crops with the result that the disparity between the fertile land and the non-fertile land was further increased. The best plan would be to distribute the available resources of organic manure on all the soils that were available in the holding of a cultivator and that was only possible if extensive research work was carried on to find out the minimum requirement of organic manure for the different soils under different types of cultivation. Rao Bahadur Viswanath referred to the efficiency of fertilisers and said that from the experiments that had been carried out it was found that the efficiency of fertilisers was lower than it ought to be. The efficiency was tested from the amount that was recovered from the crop which was somewhere between ten and fifteen per cent. only. From theoretical considerations it was considered that it should go up to twenty per cent. He concluded by saying that research was required to find out the means by which the efficiency of utilisation in the plant can be increased.

The *Chairman* suggested that those members of the Board who had submitted notes might confine their remarks to the main points of their papers so as to allow as many members of the Board as possible to take part in the discussion on this very important subject. The subject of composting was taken up first

Mr. Allan said that he had done a great deal of work in compost-making and found that there were several difficulties in getting it taken up by the small cultivator. Firstly, farmyard manure was limited on account of its being the principal fuel of the cultivator. In Baroda the question in the cultivator's family was as to who should do this work. The cultivator thought that it was his wife's duty and the woman of the house thought that she had much more work to do than compost-making. He said that it was not easy to induce those people who came back to the village every night to do composting. In the Baroda State it was the practice of some cultivators to go and settle on the land for about five or six months in the year and *these* people could be induced to do composting on their farm. Another form of manure to which he wanted the cultivator to pay attention and in which he obtained more success was urine earth as it was more easy than compost-making. He said that he was trying to induce the cultivators

to adopt compost-making and also to spread sand on the floor of the cattle shed to conserve the urine.

Mr. Narayana Iyer said that the problem of finding an adequate amount of organic manure was faced very early in the Travancore State and a considerable amount of work had been done. The problem was most important as the State had a rainfall varying from 20 to 150 inches and the soil was sandy along the coast and lateritic in the sub-montane regions. The Department of Agriculture in Travancore carried out a series of experiments on the lines that were suggested by Richards and Hutchinson in London and subsequently the process was modified according to the method adopted by the Madras Agricultural Department. The Madras method of composting in pits and covering the treated material with a layer of earth failed to give satisfactory results. A systematic series of experiments were therefore carried out on the lines recommended by Dr. Fowler of Bangalore heaping the materials on the surface and introducing a process of activation. The results proved quite satisfactory and this process has been adopted throughout the State. In the principal towns of the State the town refuse and night soil were composted in accordance with the above process and the resulting manure was readily sold. The prejudice that once prevailed for the utilisation of the night-soil had vanished and the people were ready to make use of the compost. The results of these composts were checked with cattle manure and these were found to be extremely satisfactory on crops like rice, cassava, grams, pulses, etc.

Dr. Lander said that from the manurial experiments which had been done hitherto it appeared that the problem to be dealt with was how to apply concrete facts as brought out in the various manurial trials to the individual and local requirements of any particular zamindar. He wondered what the reaction would be of a zamindar working on a small acreage of say 10 to 20 acres if confronted by those manurial results and how confused he would be if he was asked as to how he was going to apply those results. The problem was therefore to be looked at both from the point of view of general manurial requirements of a large area and of the particular local and specific requirements of any zamindar treating his own land. In the Punjab speaking generally for ordinary normal soils and omitting altogether kallar and alkaline soils, it could be stated that the soil did not usually respond in an economic degree to applications of ordinary artificial manures. The prime re-

quirement of the land was humus, and manures which should be used were green manures, compost manures and farmyard manure. The value of a compost manure would depend upon the nature of the material from which it was made and the extent to which its decomposition had preceded. It could be said quite safely that not only increased yields in crops but a very good economic return could be obtained from the application of farmyard and green manure in the Punjab.

In the case of artificial manures it was often possible to get increased returns in crop yields, but at the prevalent prices of the commodities they did not cover the cost of the manure used and of the labour involved. An endeavour should therefore be made to ascertain on the smallest possible area what manures were going to give an increase in terms of rupees after covering all working expenses. In the Punjab a series of trials was being conducted dealing solely with organic manures, composts, green manures and farmyard manures on some of the main departmental farms. On certain other farms elaborate series of trials were being made to ascertain the effects of artificial manures in conjunction with one another, and also in conjunction with green manures It would, however, be several years before the results could be published.

Rao Sahib Thadani said that in Sind they had been trying the Indore method of making compost, but it was not found to be suitable for Sind conditions. They had modified this method and evolved a new improved method of making composts in heaps above ground, instead of in pits. This had proved to be very simple and cheap and at the same time a high degree of manure could be got by this process. Fifty cartloads could be prepared per pair of bullocks every year They had issued a leaflet on preparing compost by this method and were trying to introduce this into the districts. Difficulties were, however, being experienced in making the cultivators adopt this method. The cultivators did not have the requisite time and were not able to put in the little labour required in making the composts. As regards green manuring, this process had been found to be very useful in Sind conditions. The Government of Sind had remitted the assessment on growing of green manure crops so that the cultivators might be encouraged to use this method of manuring their lands. Green manuring had now begun to be adopted as a common practice in Sind and had been found to be helpful in maintaining the fertility of

the soil on which it had been used. There were certain special crops which they recommended for green manuring among which sunn hemp and *guara* had been found to be most useful. As regards artificial manures, their experiments showed that there must be a basic dose of organic manure to which some artificials might be added with some advantage. Artificial manures had given good results in Sind both with cotton and wheat, but it was found that unless a basic dose of bulky manure was added, the results were not very good.

Mr. Jenkins said that the difficulty of introducing compost-manufacture in the villages was very real and unless it was overcome no progress could be made with the increase of organic manure from compost in the districts. Some development work was necessary in this direction, on the same lines as in the Punjab, by the formation of Better Farming Societies. Production of composts could easily and profitably be done on a co-operative basis. As regards green manuring, *Mr. Jenkins* stressed the need for the examination of indigenous weeds, especially leguminous weeds, which could serve as green manure. There were certain difficulties in growing certain green manure crops in particular areas where an indigenous weed crop might serve the purpose. At the Padegaon research station, a certain amount of work had been done in this direction and an indigenous weed (*Alysicarpus belgaumensis*) had been proved to be one of the most suitable crops for green manuring.

Major Prideaux said that indigo was tried by him but was not found so useful as sunn hemp. Urine earth was also being tried. Compost-making was done by village servants and they were getting definite returns from it. He enquired whether it was nitric nitrogen or nitrate that was utilised by the plant. He understood that in manures such as sulphate of ammonia as utilised in Egypt, and as noted by Crowther, the plants utilised it in the form of nitrate.

Sardar Sahib Ujjal Singh said that he had tried indigo on his farm first as a money crop and then as a green manuring crop. He had, however, given up doing so on account of the difficulty of ploughing in the crop. Secondly, indigo flourished well on sandy soil but not on hard soil. He had given it up in favour of sunn hemp and *guara* (*Cyamopsis psoralioides*).

Senji (*Melilotus parviflora*) had also been found to be very useful for improving particularly the inferior *kalar* soils. It gave much better results than even sunn hemp and *guara* which could not grow well on sandy soils. He had made an application to the Government of the Punjab through the Agricultural Department to allow the use of *senji* as a green manure crop and give it the same concessions as they had given in the case of *sunn hemp* and *guara*, but so far the Government had not granted that concession to the zamindars. He said that if this Board could secure to the zamindars this concession with regard to *senji*, the zamindars would greatly benefit by it.

Mr. Roberts drew attention to the necessity of keeping the economic aspect regarding the use of these organic manures more permanently before them. Referring to green-manuring he said that in irrigated tracts it did cost a great deal of money. To start with, apart from the cost of seed, ploughing, irrigation and ploughing in the green manure, they had really to take into account the value of an alternative leguminous fodder crop. That was probably the most correct way of appreciating the actual cost of green manuring as the farmer himself looked at it. He had to take into account whether if he had not grown green manure, what would have been the value of the fodder he could have grown on that particular area, and if they calculated the cost of nitrogen on that basis, he thought, they would get a more accurate idea of what green manuring in irrigated tracts would cost. There must be some very definite reason for the lack of progress in the spreading of green-manuring. The Punjab Government and the Sind Government also were giving remissions in the case of green manuring which was grown and ploughed in, but this item was a comparatively small proportion of the cost of green manuring. He then referred to the question of composting. There again he thought a great deal of work on the economic side ought to be taken up and worked out. He thought that in the future this undoubtedly was going to be the most profitable line for the various Agricultural Departments, *i.e.*, to study how to make and conserve the best material that they had available in the village and on the farm; what technique was required. Various systems should be tried to see whether it was necessary to dig pits and if so what depths of pits, etc.,—and whether similarly good results would not be obtained at somewhat less cost by gathering the refuse on the surface and treating it without having to dig pits. He stressed the very great

importance of studying and working out the economies of these various systems.

Mr. Richards referred to the difficulty of getting the cultivator to take up composting. That in general was found to be the greatest difficulty where the elaborate methods of composting which were recommended from Indore were attempted to be put into practice in the villages. It involved the carrying of all waste material from the fields to the *abadi*. It involved frequent carriage of water from the village wells by women of the household, to the compost pits. After a very short trial of getting composting of this nature going in the villages of the United Provinces, the Agricultural Department came unanimously to the conclusion that it was useless. On the farm, however, where there was an organization, it was probably as good a method as any, but it could never spread to the villages. Consequently they had adopted the modified system of preparation of rain-water composting. The waste material was stored where it happened to be in the corner of the field all through the year, until the break of the monsoon. It was then made up after the Indore method, with or without cowdung, with the help of green material. Two or three turns during the course of the monsoon ensured a very adequate breaking down, and the manure would be ready if not in time for application in the *rabi* sowings at least for the sugarcane for which most of this bulky manure was wanted in the United Provinces. This did not give a concentrated manure. Trials have also been in progress for some years utilizing various proportions of cowdung to *kutchra* and also comparing the effect of pits against similar proportion on the surface. They found that with the method in which they utilized perhaps the optimum quantity of cow-dung and urine they got a nitrogen content of compost which ran up to 1·5 per cent. In rainwater composting—either with dry cattle dung or with green vegetative matter put in to help to start fermentation—one would definitely get a very much lower nitrogen content, but whether or not that amount of nitrogen was of any great importance was a matter for chemists rather than for the layman on the chemical side to decide. His point was that the additional ·5 per cent. of the nitrogen was definitely not worth the trouble put in for making compost by the elaborate method. Where rainfall was adequate and water had not got to be lifted for the purpose of breaking down of compost, the rain-water method was spreading rapidly and satisfactorily after the minimum of demonstra-

tion. In the Eastern Circle of the Province where rainfall was 50″, preparation of rain-water composting was being taken up rapidly by the villagers.

The *Chairman* said that it would be helpful if succeeding speakers would make suggestions on practical methods of utilizing vegetable wastes under village conditions. They had a useful general discussion and it was necessary to decide how they could, under village conditions, practically improve the utilization of vegetable wastes and village wastes and make hetter use of the limited supply of cattle dung.

Mr. Low (Director of the Indore Institute) said that the original Indore technique of making compost in pits was undoubtedly difficult and rather impracticable under village conditions, but he thought that the making of compost during the rains by the method which Mr. Richards had described and which was followed in essentials at Indore was practicable. As a matter of fact, the compost obtained from the rain-water technique was not equal in value to that manufactured in pits. It depended to some extent on the material used and they had also found that the compost made by the rain-water process was not so rich in nitrogen as that made in the hot weather and during the winter. At Indore they made about 5,000 maunds during the year out of which about 3,500 maunds was made in pits and the remaining being made during rains on the surface. He was of the opinion, however, that the method of rain-water composting did offer a practical solution and it was probahly the best method at present for utilizing the vegetable wastes and manures that existed in villages.

Rao Sahib Bal (Central Provinces) thought that the method followed by him of preparing artificial compost was quite simple and did not involve much work. The material could be collected in the summer at suitable places in the fields and heaps are built up during the rains and left till such time the cultivator found time to invert them once or twice. Composts were ready for utilisation at the end of the monsoon if prepared from soft and leafy materials. If the method was properly followed, even fifty per cent. of cotton stalks could be decomposed in one season. The addition of ammonium sulphate and urine, wherever possible, helped decomposition. If thick sunn-hemp was grown on the top of the heap and mixed with the material at the time of inversion, it also helped the decomposition. Some such method must be devised to enable the cultivator to take up composting as other elaborate methods

were not suitable for adoption in the villages. Since the meeting of the last Board of Agriculture when a reference to this method was made by him, some cultivators had adopted it after being told that it did not involve much labour, or expense.

In reply to Dr. Burns' query, *Mr. Richards* said that in the United Provinces good rain-water compost was made without the addition of urine or ammonium sulphate. Turning operations could be very considerably simplified where compost was being made on a big scale by utilising heavy plough and letting the cattle do the work of turning the compost, instead of doing it by hand. It was being done by Professor Higginbottom at the Allahabad Institute and specifications of the type of plough, etc., used could be had from him.

Dr. Rege said that he found difficulty in getting the cane trash decomposed by rain-water only which is not sufficient to keep it moist. The best method under these circumstances is to plough the trash in the soil before monsoon when even this quantity of rain-fall is sufficient to decompose it. It took 2 to 2½ months to completely decompose the trash by this method.

Mr. D. R. Sethi said that compost-making had been taken up by a large number of sugar estates in Bihar. The trash was collected at the time of harvest. It was inter-layered with cowdung or with small doses of old compost. Heaps were left until the rains and turned over 2 or 3 times. The estates had found that it was best to get this work done on contract in preference to either green manuring or the carting of cowdung from their farmyards. Champaran and Saran districts had adopted it and there was no difficulty in getting small cultivators to adopt this very simple method.

Rao Bahadur Ramaswami Sivan agreed with Mr. Richards and said that it was practically useless to think of preparing compost away from the fields As far as possible, compost must be made in the field wherever there was a certain accumulation of waste and as long as that was done he believed ryot would take to it However important the manurial value of a compost might be, it was much less important than the value of the physical properties of the organic matter. It had been shown over and over again that the decomposition of the organic matter helped in the assimilation especially of phosphates. The work which he did when he was in Madras distinctly showed that mineral phosphates decomposed to a very appreciable extent whenever green manure or any decomposing organic matter was applied beforehand. What was wanted

was to produce composts in the field wherever there was accumulation of waste; that would appeal to the cultivator and would save cost of transport. The manurial value of compost was low.

Dr. Crowther speaking as a visitor said that it puzzled him to see so much interest focussed on compost, green manuring and organic manures in India after his experience in Egypt and the Sudan. Presumably all countries have the same aim in their experimental work, *viz.*, increased yield per acre, and as Egypt has achieved a particularly high average yield for cotton it might be expected that at least in irrigated tracts the experimental work in India should show some similarities with work in Egypt. It may seem a remarkable fact that neither composting nor green manuring played any part in maintaining the high yields in Egypt and the prospects of their use were not considered sufficiently encouraging to justify doing experiments on them. In Egypt, any farmyard manure beyond the requirements for domestic use is utilised usually on the maize crop in the rotation. Beyond that the crops receive only artificial fertilizers and these are in general use. Green manuring is impracticable for the land is almost continually cropped with either food or cash crops. It is difficult to discover the reason for this emphasis on the organic manures here in India.

Mr. W. Sayer wanted to know whether in Egypt the lands under cotton cultivation were fertilised by silt and whether it was a substitute for the humus and the organic matter which we endeavoured to put into Indian soils. In North Bihar it was found that so long as the humus content of the land was retained it did not matter very much what subsequent manuro was put. All tho experiments with green manuring at Pusa went to show tho tremendous difference which green manuring made in tho soil. As regards the method of composting, it was found in Pusa to be most advantageous to put in cattle to graze a leguminous crop on tho spot and then to plough the land. This method they found to be superior than growing a green manuro crop like *sunn-hemp* which had got to be ploughed. The question of rainfall was an important one. It was practically impossible to lay down a heavy manure programmo for sugarcane without ensuring adequate moisture. He instanced the trial made by a planter on Mr. Hutchinson's advice in adopting a programme of manuring to his cane crop spending about Rs. 50 per acre. The monsoon practically failed in

that year and the manured plot yielded much less than the unmanured plot. Mr. Sayer concluded by saying that the cultivator would not take such risks.

Rao Bahadur Viswanath enquired from Dr. Crowther about the distribution of rainfall in Egypt.

Dr. Crowther replied to the points raised by Mr. Wynne Sayer and Rao Bahadur Viswanath and said that the cotton soils in the Nile Delta, where the best Egyptian cotton is grown, do not now receive large quantities of silt. He suggested that the traditional belief in the value of Nile silt probably arose from the association between amount of silt and amount of water. The longer the land was submerged during the annual flooding the greater the silt deposited and the more the soil moisture content increased. As regards rainfall, the average per annum in Egypt was about one inch and in the main Sudan cotton tract about fourteen inches. The soils in the Sudan scheme bore some resemblance to the black cotton soil in Central Provinces and Central India. The cotton was sown in the Sudan towards the end of the rainy season. To Sardar Ujjal Singh's query as to whether good growth of cotton was not due to some rotational effect of cotton following a leguminous crop like berseem, Dr Crowther said that cotton usually followed maize or rice with at the most an occasional catch-crop of berseem grown in the months November to January.

Dr. Burns summed up the discussion and said that the question of manuring in theory and practice and especially composting had received attention during the last few years, largely due to Sir Albert Howards' book "The Waste Products of Agriculture", which was not so much a system of composting as a system of farming based on composting. This book had stimulated an enormous number of different types of experimentation on the making of composts to suit the varied conditions. He did not think that there was any single process which had had such an enormous number of variations, all successful. Dr. V. Subrahmanyam of the Indian Institute of Science was attempting to collect the various systems of composting and write them up in the form of a monograph.

Dr. Burns said that while visiting the Punjab last year he had found composting practically in all Grantee Farms by one method or the other. In addition to the usual materials he found people putting stuff like wheat-dust and running refuse into the composts. He referred to the remarks of Sir John

was explained by *Dr. Rege*. He further said that in the light soils of Deccan canal area due to heavy rains in September-October about eighty per cent. of the nitrate formed was leached down to the lower strata and when they planted sugarcane there was very little nitrate left in the soils. They had recently tried to retard the decomposition of sunn by mixing it with trash. Generally fifty per cent. of the trash was mixed with whatever green material was available at the time of ploughing in sunn crop and by this method they delayed nitrification of sunn by more than a month because whatever nitrate was formed it was immediately taken up by the trash. At the time of planting sugarcane setts about 20—30 per cent. more nitrate was found in the soil than by sunn green manuring alone.

Rao Sahib Bal said that he had given in his note (Appendix II) a brief review on the different aspects of green manuring which they had so far been able to investigate in the Central Provinces. With regard to the effect of green manuring on the subsequent quality of the paddy crop the results obtained conclusively showed that green-manuring alone reduces the percentage of P_2O_5 in the seed, but applications of nitrogen in conjunction with phosphatic fertilisers increase it. He thought it was necessary that the changes in nitrogen content of the soil with different green manure crops under field conditions should be studied more closely than had been done in the past. Studies on the decomposition of green-manuring plants under field conditions should also be studied with close attention.

Mr Allan said that the question of the economic aspect of application of green manure in advance of sugarcane, paddy and wheat crops required study. His experience in the United Provinces and Baroda showed that the cultivators grew green-manure only when they had no alternative crop to sow.

Mr. Narayana Iyer said that the question of growing of the green manure crop on the field and burying it into the soil was rather impossible in many localities in the Travancore State because of the very heavy rainfall which ranged from early in June to the middle of September the total rainfall being about 80 to 90 inches on the average. The most important crop grown was the rice crop. Two crops of rice were grown every year in the majority of the area available. The growing of green manuring crops was out of the question, and they were therefore growing green manuring trees. The green leaves

and loppings of these trees were ploughed into the puddled soil before sowing the paddy seeds or transplanting the seedlings. When the seedlings established themselves a top-dressing of a nitrogenous manure like ammonium sulphate was given. This system of manuring was working quite satisfactorily.

Rao Sahib Thadani referred to the point raised by Mr. Roberts of the economics of green manuring in irrigated tracts. He had mentioned that mere concession of assessment by Government was not sufficient for the cultivator to resort to green manuring. He pointed out that the Sind Government had given a further concession in allowing the cultivators to take one cutting of the crop as green fodder. That had been a great incentive to the cultivator in addition to the concession of free assessment of the crop. In Sind, at any rate, that was one of the potent sources of maintenance of the soil fertility and compared to the other sources of manuring, namely, farmyard, composting and artificial manures, they considerably relied on this process of maintenance of the soil fertility to be adopted in general cultivation in Sind. One of the methods of green manuring which they had found useful in Sind was growing, with cotton, alternative rows of *guar*. When *guar* had grown for about a month, it was buried into the soil. This experiment had succeeded in different parts of Sind. He therefore recommended that some such practice whereby along with money crop one could do green manuring side by side would be most successful and would appeal to the cultivator more than the practice of growing a green manuring crop alone.

Referring to the remarks made by one of the speakers in regard to the value of *senji* as a green manure crop, he said that as a fertilizing crop it had been found very useful though it might not be as valuable a fodder crop as berseem and other *rabi* leguminous crops, but it was very easy to grow. It did not require as much water as berseem. He therefore felt that *senji* was really a very valuable crop both as fodder and as green manure.

The *Chairman* said that the subject was now open to discussion. He drew attention of the Board to the fact that in 1935, a committee was appointed which presented a report on green manuring. He then read out relevant portions on pages 31 and 35 of the proceedings where suggestions were made regarding the directions in which investigations might be of value. The Board would be interested if speakers could mention any

instances of successful work or of experiments which had given definite results along these lines. He suggested three points for consideration. Had any definite advance been made in green manuring methods? Had they any new instances of the successful introduction of green manuring into general agricultural practice? Had concession irrigation rates, which had been tried in various parts of India with object of encouraging green manuring, produced any marked effect and what was the position in regard to such concessions at present?

The Board adjourned at 1-0 P.M. to meet again at 2-30 in the afternoon.

Colonel Maclean said that in an experiment started by Mr. Cliff in which he grew cane after a fallow, after maize and after green manuring, the extraordinary result was that the yield after green manuring was invariably lower than it was after a bare fallow. It was so marked in the last three years and on two different farms that he was thinking of altering the rotation—green manuring, cane, fallow, wheat and to bring it round the other way—green manuring, wheat, fallow cane. He had no idea why the fallow should be better than the green manuring but their results were obvious and significant. He had deputed a man to work out the economics of the whole system. As regards green manuring, planters in Bihar who had given up indigo planting and had gone in for sugarcane grew their crops without exception with sunn and gave invariably at planting time a maund of double super without which the results were not good. He always recommended *dhaincha* (*Sesbania aculeata*) in green manuring, the price of which was the same as that of sunn, but the seed-rate was half and so there was a saving of fifty per cent. in cost. Further *dhaincha* stood waterlogging better than sunn. Moreover, as had been pointed out by Mr. Hutchinson, at Pusa, in a year of deficient rainfall there was more moisture left in the soil after a crop of *dhaincha* than after a crop of sunn. In such areas germination was better after *dhaincha*. Summing up he said that the *dhaincha* might be given a wider trial.

In reply to the Chairman's query regarding the interval between the turning in of the green manure and the planting of cane, *Colonel Maclean* said that they sowed the green manuring sop at the break of the monsoon in the middle of June and got it in if possible about the beginning of August. The cane planting did not begin until the cold weather about the third

week of January, so the interval was about five months and thus there was a fairly extensive fallow.

Dr. Basu said that they had been trying some indigenous leguminous weeds on the Padegaon farm for the last three years as green manure crops and found one of the local weed *Alysicarpus belgaumensis* giving sufficient amount of green material and improving the soil tilth considerably. It seemed in no way inferior to sunn-hemp. *Dhaincha* proved successful on heavier types of soils. It was likely to improve the quality of such soils as it removed the exchangeable sodium from badly chopanised (alkali) soils.

Mr. Jenkins said that it was not an uncommon oxperience that the crop, after a green manure crop had been ploughed in, was inferior. In Europe and in England particularly, experimental work was going on on the comparative value of green manuring crops and fallows. A light dose of farmyard manure given in conjunction with green manuring crops before the green manure crop was ploughed into the soil was giving better results than green manuring alone Similar results were also obtained in Bombay where an additional light does of farmyard manure was found more useful than green manuring alone.

In reply to the Chairman, *Mr. Jenkins* said that the green manuring practice was increasing amongst the cultivators and the use of sunn-hemp had passed into general practice. No concession had been given in the way of irrigation.

Dr. Burns pointed out that at one time there was a concession as regards sunn-hemp areas. The water rates were foregone.

Mr. Jenkins said that that concession was still in vogue but there was no other particular concession. If sunn-hemp was used as a green manure, water was given free.

Mr. Mukerji (United Provinces) said they had used green manure in the case of paddy at Nagina and it was curious that green manure in conjunction with superphosphate did not bring a satisfactory yield. In other provinces in India it was the common experience that green manure when combined with superphosphate gave excellent results. Experiments were also carried out at Shahjahanpur regarding the relative suitability of different parts of a green manure plant (sunn),

although the results were not statistically significant, yet on the whole the yield figures for cane tended to show that better results were obtained with leaves than with stems. It was also noticed that in green-manured plots the nitrogen-content in the first foot of the soil was definitely higher than in the second foot whereas in a neighbouring plot which had not been green manured nitrogen just after the monsoon in the top soil was lower than in the first to second foot layer.

Dr. Padwick instanced the case of Western Cnnnda where green manures had been experimented a good deal. Eventually it was found that due to high carbon/nitrogen ratio there was an immediate depressing effect on the nitrifying organisms in the soil. Rainfall in Western Canada was very very low. After summer fallow when the land was idle for eighteen months there was great increase of nitrogen.

Dr. Burns said that in England it has been found that nitrogen in the natural manure might be locked up by drought or cold and that it could be released by the addition of artificial manure. *Dr. Rege* explained his experience in the Padegaon research station and said that so far as sulphate of ammonia was concerned it would be taken up immediately by the green manure but it would not help in the decomposition of the green manure The experiments conducted with sunnhemp showed that with the addition of superphosphates the yield was 9,000 lbs but without the addition of phosphates the yield was only 4,000 lbs *Mr Allan* said that if crops like *jowar* would be cut early and their stumps were ploughed in, the next wheat crop was a good one Mr Richards said that the question whether *sanai* (*crotolaria*) was useful or not for the succeeding crop was affected by several factors and unless one knew precisely as to what had happened it was not possible to arrive at any definite conclusion In the United Provinces the difficulty was that if there was no rain in the first part of the cold weather in unirrigated tracts the nitrogen in the soil was taken up by the decomposing green manure which competed with the crop that was sown. Consequently it was not possible to judge. He said that Mr Clarke had done a considerable amount of work at the Shahjahanpur Station on green manure along with the nitrogen cycle of soils. His conclusions were that one had to depend on two kinds of organisms, namely, fungi and bacteria before the material in green manure was made available to the plant. Unless there were right conditions in the soil one could not expect to have green manure

available for the *rabi* crop. Experiments on the various aspects of green manuring on scientific basis were now in progress at the Shahjahanpur farm and results would be available in a year or two.

The United Provinces irrigation rates definitely encouraged the development of green manuring practice. Mr. Clarke did most of the work in the Rohilkhand area with the improved Coimbatore canes, but it did not appear to have spread even though the irrigation rates were nominal. On the other hand, in the new tube-well area where there was intensive agricultural development people paid high rates and grew green manure for their sugarcane crop. Green manuring did improve the yield of sugarcane, but it was not known whether it was a paying proposition to the cultivator. In answer to the Chairman *Mr. Richards* said that the irrigation rate for green manuring in the Sarda Canal area was from annas 8 for lift to Re. 1 for flow.

Major Prideaux complained of the high water-rates for growing green manure in the Punjab. If the *patwari* found that the crop had been cut or had been grazed, the charges for growing fodder were charged. The representations made to the Government were unsuccessful. No concession was given to the *rabi* crop, berseem or *senji* and therefore the spread of growing green manure was checked. In reply to a question from Mr. Richards, *Rao Sahib Bal* replied that they had tried only one non-leguminous crop *Kodojira* (*Vernonia cinerea*) in the Central Provinces which was successful. *Rao Bahadur Viswanath* said that in regard to ploughing in there was no difference between non-leguminous and leguminous plants, but leguminous plants were preferable.

Dr. Burns summed up the discussion and said that so far as green manuring was concerned it would seem that there were many factors the effect of which was not quite understood. It seemed to be largely a question of effect of soil conditions on the manure itself. So far as sunn-hemp in the Deccan was concerned, the difficulty of depression of yield of the succeeding crop had not arisen. This might be due to the very much greater speed with which decomposition took place. The depressing effect of green manure which was not fully disintegrated might, as Dr. Padwick had remarked, be due to the increased carbon-nitrogen ratio. The green-manuring method should be adapted to suit the soil and climatic conditions. More attention should be paid to the Proceedings of the Green Manuring Sub-Committee of the last Crops and Soils

Wing in order to get some kind of coherence and uniformity in the results. He concluded by saying that a considerable amount of progress had been made and the reasons for varying results would have to be worked out in the laboratory.

With reference to manuring with artificial manures the *Chairman* said that the total supply of organic manure was inadequate and we had to consider how best it could be supplemented by addition of artificial manure. Artificial manures frequently gave their best results when they were used in conjunction with organic manures.

Dr. Lander opened the discussion on this aspect of the question, and stated that, taken on the whole the soils of the Punjab were not conspicuously lacking in plant food material other than humus and nitrogen. The soils in the Rawalpindi district however appeared to respond economically to potassium and to a greater degree to phosphatic fertilisers. Many trials with artificial manures had been conducted, frequently with significant increases but taking into consideration the total cost involved in the employment of artificials in doses so far tried and the value of the increased yields the returns in the great majority of cases, other than with nitrogenous artificial manures, were not economic. Experiments were being conducted on some of the major farms in the Punjah which dealt with both organic manures alone and with organic manures in conjunction with different types of artificials and also with artificials in different combinations It was particularly necessary to find out certain factors connected with the carbon nitrogen ratio in the soil in regard to the use of any fertiliser It was quite possible of course that the results which had been obtained in the Punjab might not be applicable at all in other provinces which had entirely different types of soil. In the Punjab they were dealing mainly with soils represented by the Indo-Gangetic alluvium which was quite different from, say, the black cotton soils of Madras.

Rao Sahib Thadani said that in Sind they always gave a basic dose of bulky manure and then added artificial manure. They had found that ammonium sulphate when applied to the cotton crop gave very useful results specially at the time of flowering Apart from the increase in yield, the seed development had been very much better. There was also a certain amount of increase in the yield of the wheat crop. The experiments on artificial manuring had been done only for two years and they were therefore not able to recommend their use to cultivators with confidence.

Dr. Burns said that the question of price must be discussed along with the question of the use of fertilisers. In Bombay their experience was that in the case of valuable irrigated crops the use of sulphate of ammonia paid but otherwise it did not. From the figures available it could be seen that the increase of sulphate of ammonia was increasing every year but the important point was to know how much of it should be applied to a particular crop. Mr. Richards had pointed out that in the case of sugarcane balanced manuring was particularly essential, otherwise there was a drop in sucrose percentage; but this difficulty had not been noticed in the experiments carried out by the Maharashtra Chamber of Commerce in the Bombay Presidency. Yields of about one hundred tons per acre were obtained without any depressing effect on the sucrose. Throughout the experiments the manure was very largely nitrogenous, water was put on in very large quantities But it was an important point to be looked into as almost all trials carried out in the anti-tropical belt showed that depressing effect on sucrose At this stage therefore it was advisable to leave the matter where it was, *viz.*, that where it paid, artificial nitrogen might be used, where it did not pay it should not be used and where it was worth while using, particularly in sugarcane, it must be used in a balanced form.

The *Chairman* said that the discussion brought out the fact that we needed more statistically valid results as to the effects of artificial manures on crop-yield. We also needed accurate records of the prices of the produce and of the manures. Without these it was not possible to state at any particular time what the system of manuring ought to be. The Fertilisers Committee of the Imperial Council of Agricultural Research had drawn attention to this point and recommended that future manurial experiments should be designed to find out the proper ratios between nitrogen, potash and phosphates as manures for different crops, careful records being kept of prices and composition of the manures and the prices of the produce.

Subject VIII.—A Review of the application of Statistical theory to agricultural field experiments in India.

The *Chairman* before taking up this subject thanked Professor Mahalanobis and other University representatives and officers of other Departments coming to help in their deliberations. He welcomed specially the University members and representatives of the Irrigation Department, who had come at

no small sacrifice in point of time. The Board was fortunate to have the presence of Dr. Crowther, whose work in Egypt was well known to many members and who had already taken part in the discussions. His advice on field experiments would be most valuable. The object of all field experiments was to enable the Agricultural Department to make practical recommendations to the ryot. Most people had a pathetic trust in averages but they might be the most dangerous things in existence. It had been recognised that field experiments must be extremely carefully planned and properly interpreted. He invited Professor Mahalanobis to open the discussion.

Professor Mahalanobis in introducing the subject said he felt honoured to open the discussion. He had no intention to inflict his long note (Appendix III) on the Board but would bring out its salient points. He then explained in detail the great changes that had taken place in the lay-out of agricultural experiments due to the utilisation of methods devised by Dr. R. A. Fisher. The first principle of this method was the application of the basic idea of sampling, *viz.*, that the plots should be representative: hence the so-called random arrangement of plots within an experiment. The second principle was that of replication, *i.e.*, repeating of plots. It was not adequate to base conclusions on a single plot. The third principle was that of local control, *viz.*, dividing up the area into blocks within which the group of varieties or treatments to be concerned was repeated. The Imperial Council of Agricultural Research was responsible for the introduction of the Fisherian technique in India. The first experiment based on these principles was reported in the *Indian Journal of Agricultural Science*, in 1931. The first complex experiment was laid down in India in 1933. He further complimented the Imperial Council of Agricultural Research for starting a Statistical Section at its head-quarters and thanked the Council for grants of funds to his laboratory in Calcutta thereby enabling agricultural officers from various provinces to visit the laboratory and get first-hand information of the theory of statistics applicable to agriculture. He said that the experimenter must be careful not to attach undue importance to an isolated result which might appear to be statistically significant and yet did not fit in with the general agricultural experience. Such results should not be ignored, but neither they should be accepted until corroborated by further experiments. On the other hand, results statistically insignificant

Dr. Crowther narrated his experience in the Sudan in applying Fisherian methods to agriculture. He started the experiments in 1928 at a time when available information was confined to the results of a few Latin Square lay-outs. By combining the four factors of sowing-date, spacing, amount of irrigation and amount of nitrogen in the same experiment, making a total of 288 plots in the one experiment, new information had been obtained on the inter-relation of the factors. Thus with a range of sowing-dates spread only over two month the early sowings were found to give similar yields whatever the spacing between plants, yield being determined primarily by the amount of nitrogen and water supply. With late sown cotton on the other hand the amounts of nitrogen and water supply available were not very important, yield being determined almost entirely by the *spacing* of the plants, close spacings being essential for high yielding. The importance of close spacing for late sowing is now widely admitted and the cultivator's practice is modified accordingly. In 1934, experiments were started in Egypt and similar multiple factor experiments on variety and manuring problems revealed wide contrasts in varietal behaviour. Thus, the two varieties Giza 7 and Maarad do not differ greatly in yield on average soils but, when manured with nitrogenous fertilizer, Giza 7 comes out significantly superior to Maarad and when manured with Superphosphate their order is reversed, Maarad being significantly superior to Giza 7. These inter-relations between the various factors limiting growth can only be recognised by the conduct of multiple factor experiments. Dr. Crowther was surprised to see so many single factor experiments in progress in India, and he particularly deplored the practice of doing single factor spacing or manuring experiments for five or ten years before making use of the results. After such a long period the varieties popular would no longer be the same as when the experiment was started, the results being out of date before publication. With a multiple factor experiment it should be possible on irrigated tracts to have valuable information within three seasons.

Professor Mahalanobis said that he was glad that Dr. Crowther had emphasised the carrying out of complex experiments. In the case of four-fold complex experiments on rice in Bengal it was found that an increased number of seedlings was necessary to make up for late transplanting. As regards irrigation they had designed one or two experiments in the laboratory at Calcutta and not thinking of laying them down

results if intelligently applied. For this reason he was not keen on sending out from the Centre any set of rules for crop-cutting experiments.

Dr. Ramdas, with reference to Professor Mahalanobis' remarks, pointed out that last year the International Commission of Agricultural Meteorology, sent out a questionnaire asking them to start phenological observations in India, their idea being to select two or three typical plants on which these observations could be based. The matter was referred to the Imperial Council of Agricultural Research and it was now with the Indian Botanical Society. A committee was taking steps to draw up a list of plants suitable for India. The subject would be referred to the next Indian Science Congress and he hoped a scheme would be formulated. With regard to permanent climatic series, the difficulty was that yield data, other than averages for an experimental farm as a whole, could not be obtained. It was therefore difficult to draw up very accurate relations between climate and the yields of crops based on such data. Dr Fisher, had drawn up a precision scheme for British workers on Agricultural Meteorology. A number of plots was assigned for this purpose, certain rows selected at random and on each row a sampling rod was placed and certain plant characters (*e.g.*, height, number of leaves, etc.) were observed: for wheat he had designed a particular sampling rod. Measurements were made at intervals during the growing season and at harvest so that the life history of the crop from the date of sowing to the date of harvesting was known. They had tried a modified form of the precision scheme with wheat at Poona and with rice at Karjat. It was proposed to discuss the results of the analysis of four years' data already available with Dr. Fisher when he came to Poona. After putting together the results obtained it would be possible to formulate a scheme

Mr. Richards said that he would add his praise for the review which Professor Mahalanobis had presented He proposed that with the permission of Professor Mahalanobis and the Board several copies of the note might be printed and circulated among the staff of the Agricultural Departments in the Provinces. Although Professor Mahalanobis had avoided giving formulæ, he suggested that technical terms in the note, *e.g.*, co-variance, standard error for mean yield per plot, etc., which were likely to form an obstacle in making the note clear to a non-mathematical and non-statistical mind, might be defined in a simple language. Growth records as

advocated by the professor was not likely to be very helpful in working up their correlation with the yield in cotton in the crop due to the unevenness of the data caused by the attack of Pink Boll worm In regard to the need of multiplicity of experiments in different areas he was up against the difficulty of knowing the number of different plots for obtaining good results. His experience in the complex trial of cruciferous oil seeds extending over four years did not give the necessary correlation of aphis attack.

Professor Mahalanobis was of the opinion that a satisfactory results could be obtained by carrying out multiple experiments at eight to ten places.

Rao Sahib Thadani said that they had been carrying out all their experiments under new methods in vogue under expert statistical advice and interpretation at one or two particular research stations in Sind While they were satisfied with the superiority of the results. the ryot to whom the results were demonstrated attached little importance if the differences from the average were small. It was not right to go to the cultivator unless large intrinsic advantages were obtained. He wanted to know the limit of percentage increase over the average variety at which the cultivator should be approached for testing the results of the research station.

He wanted to know the smallest size of plot on which he could carry out the trials to get convincing results for his own satisfaction Further he felt that results of a single trial carried out at a research station were not applicable all over. He wanted to know the number of trials required to give satisfactory results.

Professor Mahalanobis in reply to Rao Sahib Thadani said the magnitude of difference was not a point for the statistician to decide. He thought that results were within an error of five to ten per cent it was useless to demonstrate to the cultivator the results of experiments conducted in the laboratory. It was not worth spending any money on an experiment which showed only one per cent. increase in yield. Field trials in such cases should be undertaken by the Department itself and the Statistician could help the Department by analysing the data and interpreting them. In regard to the question of number of trials. the argument emphasised the carrying out of multiple trials advocated in the note. Results of research stations only hold good for research stations and it was therefore necessary to carry out a number of trials spread out in different tracts.

The *Chairman* pointed out that Mr. Thadani's question was answered by the recommendation of Sir John Russell who said that the results of carefully laid-out experiments at research stations should be translated to the cultivator's field in a simpler form and under more practical conditions. He wished to mention one more point which was occasionally overlooked. In much laboratory work on natural products soils and manures one was dealing with non-uniform material so that accurate sampling, adequate replication and the proper statistical interpretation of results were as necessary as in field experiments. He quoted as an instance the work of the Indian Central Cotton Committee on the quality of cotton. The effect of meteorological factors on the quality of cotton had been investigated at the same laboratory in co-operation with the agricultural experiment stations. Standard varieties of cotton were grown at a number of stations throughout India on a particular plan and in normal rotations and quite interesting results had been obtained on the effect of season and climate on the spinning value of cotton.

Mr. Jenkins suggested that Professor Mahalanobis' note might be published in the Council's journal as it would be of much value to many readers Professor Mahalanobis said that he had already agreed to collect the data as regards standard error in regard to all the provinces in India and to re-write the whole note as the one submitted to the Board was written in haste, and contained data pertaining only to Bengal and Assam. The Chairman promised that the revised note would be published in the Indian Journal of Agricultural Science.

The Board adjourned at 5-15 P.M. to meet again at 10-30 A.M. on Tuesday the 7th December 1937

PROCEEDINGS.

Second day.

The Meeting commenced at 10-30 A.M.

Subject I.—A Review of Soil Survey work in India upto-date with suggestions for the future.

The *Chairman* said that the Royal Commission on Agriculture in India had recommended that soil surveys should be undertaken mainly in connection with specific problems. Sir John Russell had by inference commended this method of approach in his recent report At the last meeting of the Crops and Soils Wing, the same view was taken and suggestions were made as to how the information collected in the course of such local surveys could be co-ordinated.

Two conclusions were arrived at during that meeting and these were recorded on pages 22 and 23 of the Proceedings: These were:—(1) That there was a great necessity of soil surveys in connection with any new irrigation project—a point on which Sir John Russell had laid great emphasis. (2) Co-operation with the Geological Survey of India in the matter of soil surveys was most desirable.

Mr. Jenkins enquired if it was the intention to frame resolutions later on on the subject. The Chairman replied that as this meeting was mainly intended for the interchange of opinions amongst research workers and agricultural officers resolutions were not necessary unless they emerged from the discussion. Any resolutions which seemed necessary could be framed at the end of the debate.

Dr. Basu then read a summary of his paper (Appendix IV) reviewing the soil survey work in India up-to-date and made the following recommendations:—

He would recommend the formation of a Soil Bureau under the control of the Imperial Council of Agricultural Research whose function would be—

(i) to guide and co-ordinate the soil survey work all over India on the different soil groups already outlined.

(ii) to collect and compile all the available information on the Indian soils.

Three different sources of such information are (*a*) the Settlement reports (*b*) records of the Geological Survey of India and (*c*) the reports of the agricultural departments of different provinces.

Lahore. Both these organisations dealt with the problem of *Kalar*. A considerable amount of lnnd had gone out of cultivation and a great deal more was going out of cultivation on account of *Kalar*. The Department had therefore to investigate the problem and to determine whether a particular soil was alkaline or was likely to become alkaline before any irrigation projects were undertaken. Along with this survey work it was also necessary to keep a check on soils which were being irrigated by canals or tube-wells. This would enable one to keep a periodic check on such soils and so ascertain whether they were becoming alkaline. It is a common experience that shortly before becoming so definitely 'kalar' or 'alkaline' as to render plant growth almost impossible, soils frequently give bumper crops, so that the condition of the crops may deceive one as to the actual condition of the soil. The Irrigation Department was working in collaboration with the Agricultural Department but was confining its attention to large scale kalar survey work. The Agricultural Department had recently reconsidered its policy and the future programme of work to be carried out had been laid down on the following three main lines :—

(1) To take a small area of land of say twenty-five acres, which was known in places to show a tendency to develop kalar and to map this out carefully in sub-units so that soil bores could always be accurately located at a future date, and to keep a careful check on the composition of the soil from year to year down to a depth of 10 feet or more In the Punjab the periodic trouble, known as 'Cotton failure' is suspected to have some connection with the concentration and types of salts in the soil Such a study as the one just indicated may throw some light on that phenomenon and would constitute an intensive but very localised soil survey.

(2) The Departmental Farm at Lyallpur has been selected as a representative farm unit for careful analysis into soil types, *viz.*, good, intermediate, and poor terms based on the known qualities of these soils and the crops they produce. These soils types will be studied by combining careful analytical work with crop products and manurial practice.

(3) The Punjab can be divided roughly into climatic belts of more or less even rainfall. Soil profiles to a depth of 10 feet will be taken throughout one of these rainfall belts for the purpose of preparing a soil map and the work extended to other belts in due course.

The *Chairman* invited Mr. Bigsby and Mr. Bedford, Chief Engineers, Punjab, to give some account of the work that was being carried out in the Punjab Irrigation Department.

Mr. Bigsby explained the aerial photography method for determining the *kalar* areas in the Punjab. The white patches in the photographs showed places affected with *kalar*. The photograph showed that the estimates of *patwaris* were inaccurate. The definition of a *kalar* area was one which did not produce a four anna crop. The aerial photograph survey could be carried out with an error of only five per cent. and this method was considered to be more suitable than sending out squads to determine whether a soil was *kalar* or not. The Punjab Government were considering carrying out a much bigger survey by this means.

Mr. Bedford said that the Punjab Irrigation Department was greatly interested in the movement of soil salts. So far they had been dealing with the problem by digging surface drains They had not been able to tackle the question by lining the canals as it was a very big and expensive job. The soil might be described as a bed of sand with loam or clay on the surface as a lid. It had been seen from the sub-soil water contour plans that along the main canals there was a definite ridge in the water-table. In fact it was so marked that in the plan without the main canals the canal could be marked out by the ridge. This ridge disappeared near the tails of the bigger canals. The suggestion that was put forward for this phenomenon was that the amount of clay below the bed of the larger canals was small and there were certain regions where there was no clay below the bed at all and so a large amount of water reached the sub-soil from the larger canals. The irrigation department was seriously thinking of lining the larger canals to stop such leakages The Research Institute of the Punjab Irrigation Department believe that a high degree of impermeability could be got by mixing earth with a certain amount of sodium carbonate. This was also being examined. Referrring to a point in Dr Lander's note he pointed out that a bumper crop immediately before the land deteriorated, might be due to the point from where the roots of

the crop could get a good deal of moisture and produce a bumper crop. This water threw out the salts as well and when the salts reached the surface the land went out of cultivation.

The *Chairman* suggested that the discussion should now proceed on soil surveys in relation to irrigation and alkali problems and returning later to the question of soil surveys in general. He invited Dr. B .K. Mukherjee to speak on soil work in the Sarda canal area.

Dr. B. K. Mukherjee said that Dr. Basu had suggested that the soils could be classified into eight broad divisions, *i.e.*, desert, alkali, black cotton, red, yellow, forest and hill, laterities and meadow soils. Notable advances had been made in soil survey investigations in some provinces, chiefly Madras and Bombay; but the progress of the work in other provinces was not quite so marked. He thought it would be very much simpler if to start with a nucleus was formed as suggested by Dr. Lander on a small scale. This nucleus, however, small, must precede all attempts to classify the soils of each province on an ambitious scale chiefly because the magnitude of the work in India varied and also because of the limitations that existed in provinces in regard to men and money to undertake any large scale projects of this nature. Once comparatively simple facts were known, it would not be difficult to consolidate the results and classify the soils according to the various groups of the thermogenic division following the genetic system of soil classification or into divisions of Pedocols or Pedalfers following Marbut's system of classification Recognising this fact, the Soils Committee of the Board of Agriculture, at its meeting held in February 1935, recommended that such simple data as texture, colour, level of water and pH values etc., for typical soils should be recorded and having determined those facts monoliths should be prepared before embarking on a detailed soil study. Accordingly a preliminary survey of the more representative soils of the United Provinces has been undertaken which includes the preparation of soil monoliths from three different soils including *usar* or alkaline soils. Monoliths from alkaline soils did not show any marked variation in horizons except that a line of *Kankar* or lime-stone nodules occurring at a depth of about 3½ feet. The division of the profile into different horizons was well marked in the other two cases. Such monoliths are likely to prove extremely valuable for studying the composition of the soil at different depths of the profile. We do not come across a wide variation

or percentage of lime in the normal soil profile although percentage of clay varies very much in different horizons. Monoliths represented the true characters of the soil in different tracts. In them the natural soil formation is truly represented and they can be maintained permanently for reference in the future. If monoliths of important soil types were prepared in all provinces and collected at a central place so as to be available to different soil workers in India it would be a very convenient arrangement. Dr. Mukherjee further explained the details of work in progress. The United Provinces soils could be divided into four definite groups:—

1. Indo-Gangetic alluvium.
2. Bundelkhand tract below the rivers.
3. Hill tract—a distinctive group of soils of very heterogeneous nature.
4. Bhabar tract—a narrow strip at the foot of the mountains.

Soil surveys were carried out of the orchard at Chaubattia and it showed great variance even at small distances. A soil map of the orchard is prepared taking profiles as unit of study—The soils are definitely acidic; pH value decreasing with the depth of the profile. Contrary to expectation the pH improves with the increase of the organic matter. Silica varies from 4·5 to 18·5. As the weathering progressed complete mineralisation occurred.

Regarding investigation in the Sarda area. Dr. Mukherjee explained that a short time ago a scheme was formed for conducting soil survey on a small scale in the tract between Unao and Lucknow. That tract represented almost all the true soils of the United Provinces. Certain reclamation work was going on, but the chief difficulty was the rise of the water-table. By carrying out a survey of the areas adjoining the canal-irrigated tracts, it was found that a large part of the area which was at present uncultivated, could be reclaimed by the simple process of leaching and cultivation. These soils were known as *Purthi*. The most difficult thing was to reclaim those areas which did not yield results by leaching or by following improved methods of cultivation. The soil was troublesome because of the presence of large quantity of exchangeable sodium in it. To bring that soil into normal condition would probably mean the replacement of the exchangeable sodium by calcium. A scheme to this effect had been submitted to Government.

Mr. Richardson said that so far as old canals went, broadly speaking, they had no soil deterioration problem. They had heard from time to time of soil deterioration from Settlement Officers, but previous Settlement Officers had made exactly similar remarks and an examination of maps and records do not show any definite deterioration in tracts irrigated by canals. They had possibly been saved from this trouble by the fact that they were short of canal water. The intensity of irrigation in the United Provinces was lower than in some other provinces. They also had deep-cut natural drainages and many miles of artificial drain had been constructed from the early days of irrigation There were two miles of drain for every three miles of canal and he presumed that for that reason they had escaped trouble. The Sarda canal had only been recently constructed and it remained to be seen whether the trouble will arise there. So far as their observation went the spring level as recorded in open wells showed fall rather than rise and not as pointed out by Dr. Mukherjee.

Mr. Stewart asked for information as to the nature of the work which the drains did. Were those drains rain-water drains or seepage drains as well?

Mr. Richardson said that, generally speaking, they were rain-water drains although some of them carried seepage water as well The vast majority of them were rain-water drains.

Mr. Stewart enquired from Mr. Bedford what was the extent or the intensity of the soil survey which had been made preliminary to the Haveli project which was to be started.

Mr. Bedford said that soil survey was made by their Research Institute and it was based on the method of sampling—one sample for every 400 acres. They were now examining the question to see what further soil survey should be made. The construction of the canal had already started. The object of the soil survey was to get help for their colonisation work so that the land could be given to allottees with certainty. There would not be so many changes in the allotment as used to be in the past years They had not yet decided what further degree of accuracy was required for the soil survey.

In that connection there was one point which he would like to mention—On the lower Chenab Canal there were large areas which were now ruined but which a few years ago were excellent agricultural land. He was not quite sure that a soil survey would be applicable some years after the canal had been

in operation. It could merely be a guide to know that certain lands were obviously unfit. But it would not indicate what soils were going out of cultivation in future. The Irrigation Branch had decided to completely line the main canal in the Haveli Project from head to tail at a cost of 55 lakhs of rupees because it was so much easier to do the lining at the beginning than to wait for trouble and try to deal with it afterwards.

Prof. Mahalanobis enquired from Messrs. Richardson and Bedford the order of the slope of the drainage channels. While examining a similar question in Bengal he found that a great difficulty in carrying off rain water quickly was insufficiency of slope.

Mr. Richardson said that there were two questions, (i) the order of the slope and (ii) the intensity of the rainfall. On the Sarda canal it varied from eight feet a mile at the head to one foot a mile at the end. They generally tried to keep it to the minimum of two feet per mile. As regards the intensity of rainfall, they allowed for a run off varying from ten cusecs per sq. mile down to two cusecs per sq. mile depending on the intensity of irrigation and nature of the soil.

To the *Chairman's* enquiry as to the extent of reclamation work which was undertaken by the irrigation department in the area mentioned by Dr. Mukherjee. *Mr Richards* said that, on this specific question of investigations in the Sarda Canal area, their chemical staff was so limited that it was not possible to provide for any very extensive work They were hoping to augment their small chemical department which might enable them to undertake this work on a bigger scale. In the first instance, what Dr. Mukherjee was already carrying out on a small scale was the examination of *usar* and semi-*usar* areas on which no reclamation work was proposed to be undertaken. This would give information as to the conditions prevailing in those areas before any ameliorative work was carried out. They would be able to follow up the results by a soil survey and cropping and see later whether there was any possibility of water-logging and consequent alkalinity.

Rao Sahib Thadani said that it was not possible to carry out any detailed soil-survey work in Sind owing to heavy cost. Some preliminary work had been done by the research division of the Public Works Department. They had collected certain field data based on the examination of the surface including presence or absence of *kalar*, growth of crops or flora and

texture of the soil up to three feet. They had tried to classify lands into three classes, *viz.*, A, B and C, on a score card system alloting 200 marks for surface examination and absence of *kalar* and one hundred marks on sub-surface examination up to three feet, and one hundred marks for flora and growth of crops. The lands getting marks between 301 to 400 were A class lands, *i.e.*, the lands which could grow good crops without any special improvement. The lands classified as B were considered to be such lands which would grow good crops after certain improvements had been carried out. Such lands were allotted 201 to 300 marks. C class lands were waste lands which required expensive improvement development and would not grow good crops. Such lands were allotted marks below 200. This system of classification was examined by a special committee consisting of one agricultural officer, one revenue officer and one irrigation engineer who went over and inspected several areas as an experimental measure extending over about one hundred acres and they judged it from their own experience only looking at the surface. On comparison of these results, it was found that the system adopted by the Research Division of the Publio Works Department in Sind, came very near to the classification made by the Expert Committee. Now it was the question whether such a system of classification could be adopted for revenue purposes in which case they might be able to offer a certain amount of field data about surface conditions as well as sub-surface conditions and which might be helpful in considering whether the assessment could be graded according to such classes of lands A similar survey could be carried out after ten or twenty years as required As regards the cost of such a system they found that it costs only one anna per acre by maintaining a regular division in which there would be one officer and three or four classifiers or graders.

Mr. Jenkins enquired if they were still keeping records of the rise or fall in the sub-soil water-table in Sind as especially in rice-irrigated areas considerable danger might arise from the rise of sub-soil water. The Research Department of the Public Works Department used to keep a close watch on this and it would be interesting to know what the present position was. He added that the Chief Engineer of the Punjab had mentioned that a rise in the sub-soil water-table often resulted in a bumper crop before the land became useless due to excess of alkalinity He had found that, in Sind, bumper crops were often produced immediately after reclamation, the real reason

being that the salts on the surface, if not in excess, had a tonic rather than a toxic effect. This was also supported by the fact that certain zamindars often applied a certain amount of such surface salts to their lands as a top dressing. He was glad to know that the canals were being lined in the Punjab as considerable damage had been done by seepage water from the Rohri canal in Sind which runs actually through a sand layer bed for about thirty miles of its course.

Rao Sahib Thadani said that the observations on the sub-soil water-table were still being continued by the Research Division of the Public Works Department in Sind. They had had no such report of the sub-soil water coming up on the left bank but there was a rise on the right bank. It was still far from the danger zone. As regards the usefulness of salts on the surface of the soil, he agreed with Mr. Jenkins. Their lands were saline but unlike Punjab they were free from sodium carbonate and instead contained plenty of calcium carbonate. The observations of the sub-soil water were being taken very carefully by the Research Division and as soon as it was observed that the sub-soil water-table was likely to rise to such an extent as to affect crops, it was proposed to get the best advice and see what warnings could be given in that direction. In reply to Rao Sahib D. V. Bal the Chairman said that what Rao Sahib Thadani meant by absence of sodium carbonate and presence of calcium carbonate was that in Sind the alkali in the soil was not mainly due to sodium carbonate but due to sodium chloride and sodium sulphate.

Mr. Roberts enquired from Mr. Richardson as to whether there had been any appreciable drop in the water-table in the area covered by tube-wells in the United Provinces. One of the methods of preventing the rise of water-table was probably the installation of tube-wells which had been advocated in certain areas like Khairpur-Sind. Pumping had shown a good effect in that area. He had learnt from the address delivered by Sir William Stampe in Lahore that there had been no appreciable drop in the water-table in the United Provinces

Mr. Richardson said that the full number of tube-wells provided for in the project had been functioning only for a small period. Construction had only recently been completed and the full number only started functioning at the beginning of the last *Kharif*. It was too early to say what effect they would have on the water-table He personally, however, viewed the position with some apprehension.

Mr. Stewart, referring to the rise of the water-table and the formation of *kalar* soils, that they were accustomed to believe that the *kalar* problem was due to the rise of saline sub-soil water by capillary action, but at a recent meeting of the Punjab Water-logging Board Dr. Mackenzie-Taylor's report indicated that it was not necessary for the saline sub-soil water to rise to the surface for the production of *kalar*. The great variation in the humidity between night and day temperatures in the winter time was sufficient in itself to form salt crystals on the soil surface. Mr. Stewart said that the humidity in the day time was of the order of thirty per cent. and in the night time it was seventy to one hundred per cent.

Mr. Mehta (Land Reclamation Officer. Punjab) corroborated the statement of Mr. Stewart He said that experiments had shown that it was not necessary that the water-table should be saline. Even in cases where the water of the water-table was sweet, salt had appeared at the soil surface.

On the suggestion of Major Prideaux, *Dr. Crowther* described the soil conditions in Egypt and the Sudan and said that the clay content in the Sudan was considerably greater than any he had heard of in India. There were other important factors besides pH values of alkaline soils and he was of opinion that attention should be concentrated more on the amount of clay—collcidal material in the various soils. Thus a Punjab and a Sudan soil may have similar pH values, but the alkaline condition in the Punjab soil is likely to be much more harmful to crop development than that in the Sudan soil, because one contains so little and the other, so much colloidal material. The work of Prof. Dastur on 'Bad Opening of American Cotton' at Lyallpur was indicating how harmful these Punjab salts might be. In a heavy soil the clay serves to buffer the whole soil so that the salt content can go to quite high limits without deleterious effects and far beyond the critical salt limit of lighter soils.

Dr Burns said that so far as he remembered Dr. Ramdas' work at Poona the layer of soil which absorbed water in night from the air and gave it up in the day was very thin. (Dr. Ramdas said it was about two inches). Dr. Burns questioned if movement in so thin a layer would have any effect.

Dr. A. N. Puri explaining the problem, said that it was he who was responsible for propounding this theory of soil humidity. The two things that should be remembered were

that the absorption of moisture by the soil from the atmosphere was conditioned by the amount and the nature of the salt contained in the soil. There were certain salts which would absorb moisture to a greater extent than others and would thus make the soil more hygroscopic. The soil which contained such salts absorbed more moisture. Another extraordinary phenomenon was that the movement of the salts upwards was in a vertical direction. His observations showed that there was enormous variation in salt deposition in the soil even within a short distance. He described an experiment which he was conducting and said that he was devising a rapid method by which a mere examination of soil profiles would indicate the amount of alkalinity present in the soil.

The *Chairman* said that it was clear that more attention has been paid to the soil research since the last meeting of the Crops and Soils Wing and considerable progress had been made along the lines suggested by the Board. It was satisfactory to note that work on more studies of profiles were being undertaken. The general question of soil surveys was then taken up.

Dr. Burns said that the important point in Mr. Gorrie's note was that in soil surveys the various factors which cause erosion should also be taken into account. He referred to the work done at various Dry Farming Research Stations specially at Sholapur where records of the soil washed away by the monsoon and other factors causing erosion were being studied and maintained.

The *Chairman* invited Rao Bahadur Viswanath to explain the work that he had started to follow up the recommendations of the last Board of Agriculture.

Rao Bahadur Viswanath said that as a result of the discussion at the last Board meeting two conclusions were arrived at—(1) a soil survey of some sort was necessary and (2) we should not spend money and do it. In the meantime there has been a certain amount of discussion among soil chemists on the exact methods to be followed. The time had arrived when something specific should be done as there was need for information in regard to the general make-up of soils in this country. It was necessary in the first instance to concentrate attention on a general soil survey of the country and then devote attention to more local and specific problems. He had been looking to publish data of soil surveys of various Agricultural departments and by means of the data collected

therefrom he had prepared a small skeleton map of the important typical soils of the country. Copies of this map would be forwarded to all soil workers for corrections, additions and alterations with respect to their definite localities In the course of soil mapping it has been found that a great majority of the plains area is constituted of alluvial soils or transported soils. The collection of information would throw more light on the specific processes that had been responsible for the formation of the soils Samples of soils from cultivated and uncultivated areas to the depth of 5′ to 6′ had also been collected from typical experimental stations in India, the idea being to examine all the collected profiles by a set of chemists experienced in analytical work and by a set of methods selected however arbitrary they might be .When the data are collated and mapped and considered along with the data already available in the provinces it might be possible to proceed a step further and then concentrate attention on localised areas. It might be possible in this way to build up a fairly reliable soil map of the country In the course of the study of some of these profiles interesting information had already been obtained. In Indo-Gangetic plain where rainfall is low, lower strata are characterised by concretions of calcium sulphate. On the other hand, in fairly moist areas lime concretions are found. In the south in black cotton soils gypsum is found wherever rainfall is less Continuing Rao Bahadur Viswanath said that he was associated with the surveys of alkaline soils of the Tungabhadra Survey Project One of the conditions then laid down was that in every soil survey started, an Engineer was to look after the irrigation side of the soils. He was of opinion that a scientific staff should also be maintained to watch how the soils behaved under continued irrigation Before he left Madras, the Madras Government had accepted the proposal and appointed a small staff He did not know what the conditions were now.

Dr Ramdas pointed out that in Dr Basu's note (Appendix IV. on page 229) reference was made to Lang's "rain factor". namely the mean annual rainfall divided by the mean annual temperature in degrees centigrade. It was mentioned that stations having a similar Lang's factor often differed widely in their soils and that the rain factor might not provide a useful basis for soil-classification. He was of opinion that in considering the climatic basis due regard should be paid also to the influence of wind and the saturation-deficit of the atmosphere Evaporation divided by rainfall or evaporation

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minus rainfall was a more promising factor and would not lead to large discrepancies like those found while using the Lang's factor. Considering evaporation minus rainfall, it was found that the Bombay-Deccan, the Western portions of H. E. H. the Nizam's Dominions, Rajputana and Sind were areas where evaporation was much in excess of rainfall, whereas the west coast of India and of Burma were areas where rainfall was very much in excess of evaporation. Other areas had intermediate values.

2. If one travelled from Poona to Bangalore one came across undulating and uneven country. Wherever there was slope there was reddish colour. At the bottom of the valley the soil transported from the hill-sides by rain water and mixed with vegetative matter was black. The depth of the red colour was almost in proportion to the slope of the locality. Slope was an important thing to be taken into consideration while making a soil survey

3. When one came to the methods available for analysing the soil, mention might be made of a new method recently discovered in Sir C. V. Raman's laboratory. This was an optical method of determining the size and shape of soil particles. One had simply to prepare the medium and send a beam of polarised light through it and take certain observations on the polarisation of the light scattered by the particles. The observations did not take much time and the method should prove useful in soil work.

Dr. Basu in reply to Dr. Ramdas' objection said that the Lang's factor was selected for characterising soil climate only as an approximation. Meyer's saturation deficit equation equally shows the same anomaly that under similar climatic conditions dissimilar soil types were found to occur. None of the factors was, however, very accurate according to Robinson for measuring the extent of soil leaching. Both factors were more or less approximations only As regards the second point that red soils were found on ridges and black soils in the valleys of Deccan the explanation was to be found on the water relationships in soils. Due to topographic situations the soils on the top remained moist for a very much shorter time than the soils in the low lying areas as altered by topography.

Rao Bahadur Viswanath said that Meyer's factor had proved admirable for demarcating dry, wet and wetter divisions. It gave considerable information in interpreting soil processes when the whole country is considered as one block.

Dr. Puri said that the whole of the Punjab was a vast tract of alluvial soil. He could find no distinct horizons in the numerous soil profiles observed by him. It was therefore not possible to classify the soils on any other basis but the physico-chemical analysis of the soil profiles. The structural characteristics described by other workers were rarely present. Since the soils were transported geology did not help nor the climate which was not greatly different in the various parts. The soil classification which he advocated was that based on the single-value soil properties, the practical importance of which was discernible with eye The most important work in this connection was the standarisation of methods of soil analysis: unless that was done no progress could be made.

The Chairman invited Mr Jenkins to move his resolution.

Mr Jenkins drew the attention of the Board to the practical importance of the methods adopted for soil classification in oil surveys especially in view of the fact that, now-a-days, many recommendations with regard to irrigation practice and to agricultural technique, *e g*, manuring were being based on the results of soil surveys. Referring to the first paragraph of Dr. Basu's note, he said that in many parts of India soil classification was being carried on by methods which were now realized to be out-of-date and he contended that this, in the long run, was bound to lead to confusion For instance, in the Bombay-Deccan soil classification had been carried on for many years by the Irrigation Research Division which was based largely on the depth of the soil, on its colour and on its consistency, no account being taken at all of the soil profiles or of the different horizons within the soil profile. Since the genetic system of soil classification had been applied at Padegaon soils in the same irrigation class have shown different reactions to irrigation. There were soils in the same group of the Irrigation Department's classification which on application of irrigation water became alkaline and others which became acidic. This showed the unsatisfactory nature of the older classification. Finally he moved the following resolution for the consideration of the Board:—

> **"The Board recommends that in all future schemes of agricultural or irrigational development involving soil surveys, the genetic system of soil classification should be adopted in order that recommendations regarding irrigation and agricultural technique which may be based upon the results of such surveys, will be founded upon the most**

no alkali problem. The trouble was to get water into the land and not to get water out of the land, which was generally speaking, the case in the Punjab After explaining the soil condition in Madras he stressed the importance of carrying on a soil survey which could be immediately useful to the agricultural officers.

The Board adjourned at 1-00 p m to meet at 2-30 p. m. in the afternoon

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The resolution moved by Mr Jenkins was placed before members for discussion and approval

Sardar Ujjal Singh asked the meaning of the 'genetic system of soil classification'. The Chairman said that this was explained in Dr. Basu's note (Appendix IV. page 228)

Dr. Mukherjee, speaking on the resolution, said that the resolution as it stood was a very sound one and it ensured uniformity among different soil workers in India. He, however, suggested that for the words 'the genetic system of soil classification should be adopted', the following words should be substituted, *viz* , 'steps should be taken to adopt the genetic system of soil classification' In making this suggestion Dr. Mukherjee said that in dealing with the soil classification, taking India as a whole, a lot of latitude should be allowed in following any system of soil classification The genetic system, as it was strictly followed in Europe and America, could be very well adopted in some parts of India for soils developed from definite geologically known rocks The soil conditions in the north of India were rather different from those in the South. The depth of the soil also varied greatly. It was also known that soil profiles in the north did not show any distinct horizon. The workers might be allowed to use the genetic system of soil classification, but the individual soil workers should be left to their own resources and should be left free to alter the methods wherever it became necessary in view of the peculiar soil conditions Dr. Mukherjee was entirely in favour of the system of examination by profiles. taking that to be a unit of study. In addition to the various characters already studied, the dynamic character of the soil should also be studied.

Rao Bahadur Viswanath approved of Mr. Jenkins' resolution as amended It was necessary that instead of the words 'should be adopted' in the resolution, the words 'steps should be taken to adopt' should be substituted because there would be considerable difficulties in adopting for the great majority

of the soils of this country any system of genetic classification straight away. First of all, when all the existing data had been collected, the soil workers must agree on a system of uniform nomenclature, which might fit in with that obtaining in international circles.

Dr. Puri suggested instead of the words mentioned above, the words "steps should be taken to find out if the genetic system of classification was applicable to Indian soils". The Chairman said that the words 'steps should be taken to adopt' covered any preliminary enquiries necessary. Dr. Puri's amendment would negative the purpese underlying in the resolution.

Mr. Gosta Behari Pal (Agricultural Chemist, Bengal) was also in agreement with the amended resolution but pointed out that it might not be possible for some of the Local Governments to follow the resolution as it had been passed. Necessity had been felt in Bengal for soil surveys of a restricted nature in connection with the new irrigation projects that were going to materialise. In that connection they wanted to know what amount of water was required to saturate the soil and what was the loss due to drainage or to evaporation They also wanted to know the water requirements of crops so that sufficient water might be available for the crops that were to be grown in the new area that was going to be covered by the irrigation project. At present rice was the only crop grown in the province. In view of the already heavy programme of work in connection with irrigation project, the Bengal Department of Agriculture might not be able to do the right sort of survey of the soil although they might be able to spare money enough to take up such restricted soil surveys He therefore suggested that latitude might be given to the provincial departments to undertake such restricted work on the proposed lines.

The Chairman made it clear that the intention was that when local soil surveys were made up, profiles should be properly examined so that material for a genetic survey would gradually be built up.

After a further discussion of verbal amendments, Dr. Burns proposed that the *resolution* should be amended to read as follows:—

"The Board, while recognizing the need for soil surveys of limited nature for special purposes and to suit local conditions, recommends that, in addition, in all future schemes of Agricultural or Irrigational Development involving soil

surveys, steps should be taken to adopt the genetic system of soil classification, in order that recommendations regarding Irrigation and Agricultural Technique, which may be based upon the results of such Surveys may be founded upon the most modern and fundamental conceptions of soil science and that the results of such work in different parts of India may be more strictly comparable".

The Resolution as amended was *carried unanimously.*

Subject IV.—A review of the plant breeding in India with suggestions for the future.

Dr. Pal, in introducing his paper (Appendix V) said that with regard to the past history of plant-breeding so much work had been done during the past three decades that it was quite impossible in the space of a few pages to give an adequate account of that work He, therefore, attempted in his note to describe some of the outstanding achievements in the case of six important crops, namely, wheat, rice, cotton, sugarcane, linseed and tobacco and also to indicate briefly the methods by which these results had been achieved. The summaries were by no means exhaustive and were prepared merely to give an idea of the sort of work that had been done so as to form a basis for discussion.

The work of the Indian wheat-breeders was internationally known and a brief account of that work was given in the note. The series of wheats produced at the Imperial Agricultural Research Institute was interesting in that it illustrated the different methods that had been used in wheat-breeding. The earliest Pusa wheats were produced by making selections from the mixed country crops. Later wheats, like Pusa 52, Pusa 80-5 and Pusa 165, had been produced by hybridization either between indigenous varieties or between an indigenous variety and an imported variety Then again varieties like Pusa 111 and Pusa 114 had been introduced by taking advantage of naturally occurring mutations and natural crosses. The work on wheat in the provinces had been equally successful. The improved variety produced by the Punjab Government—Punjab 8A was reported to be now covering an area of 2½ million acres. There were also other excellent varieties produced in the Punjab, United Provinces, Central Provinces, Bombay, Sind and elsewhere.

Rice was, from the point of view of acreage, perhaps the most important crop of India and its importance had been reflected in the amount of work that had been done. He pointed

out that according to one authority there were at least 7,000 varieties of rice in the world of which India possessed about 3000. The list of improved varieties now available was extremely large. Owing to the vast amount of material available naturally, ordinary selection had been the main method by which improvement had been effected and it had given very good results. Recently hybridization had been utilized more and more. In Burma and Bengal and also elsewhere the best American varieties such as Blue Rose had been crossed with the indigenous varieties with the object of improving the quality. This was specially important from the point of view of countries like Burma which had a large export trade.

Cotton was another important crop and its importance had been recognized by the formation of the Indian Central Cotton Committee and the work of cotton improvement had been greatly facilitated by the establishment of the Institute of Plant Industry at Indore and also by the establishment of the Technological Laboratory at Matunga the work of which was well known to this Board. One special problem in cotton production had been due to the practice of adulteration, the practice of importing inferior cotton into areas which were well known for producing high quality cotton. One method by which this was being combated was by creating special islands where superior varieties known to be suitable for those tracts were being cultivated. The question of breeding varieties for such islands was therefore very important. A brief account of cotton work was given on page 241. Useful varieties were now available both of the Asiatic cottons and the acclimatized American cottons.

The work on sugarcane was very important and had attracted attention outside India. The sugarcane area in India might be divided into two main tracts—the tropical tract (Peninsular India) and the sub-tropical tract which covered the Indo-Gangetic Plain. The south was suitable for growing thick canes and the northern area, which was much more important was not suitable for thick canes, and only thin, hardy, fibrous, indigenous varieties, generally not suitable for sugar production, were originally grown. What was required was a type of cane adopted to the short season of the sugar tract, with high sucrose-content and adequate yield. The sugarcane plant did not flower very freely under conditions in Northern India. The work at Coimbatore consisted in the collection and acclimatization of as many species and varieties as possible and the study of their flowering habits with the object of inducing as many of them as possible to flower, etc. One of

the earliest crosses which was attempted was between the best available sugarcane and the *wild* sugarcane and from those crosses a number of very successful varieties have been produced. Further crosses have been made with sorghum and bamboo.

With regard to oilseeds, Dr Pal said that after the Ottawa agreement linseed had risen in importance. What was required was a high yielding linseed with white or yellow seeds. Rust-resistant varieties had been produced in the United Provinces and Bihar.

In the case of tobacco what was now wanted was a leaf suitable for cigarettes Two imported kinds of tobacco (Harrison's special and Adcock) had been tried extensively in India.

He then referred to the work that was being done by new methods, *e.g.*, using X-rays to produce mutations. In Russia they have made a cross between wheat and a perennial grass (*Agropyron*) which was expected to give great results. The process of vernalization has been applied to Indian crops at Pusa and elsewhere but the results obtained so far had been rather disappointing Breeding for disease resistance now recognised to be one of the most fruitful lines of research was increasingly appearing in the programme of Indian plant-breeders. A few suggestions regarding future policy of work were also made. These were—

(1) To avoid undesirable over-lapping and duplication of work crops may be divided into 2 groups, *i.e.*, (*a*) those with very limited adaptability, *e.g.*, rice and (*b*) those with very considerable adaptability, *e.g.*, wheat and to restrict the breeding work of crops like wheat to two or three main stations. Such restriction of breeding stations would not only result in greater economy but would ensure the greater uniformity of product which is so important from the marketing point of view.

(2) Problems like vernalization, X-ray treatment, cytology and improvement of technique and standardization of methods should be handled at one or two central research stations where extensive collections of crops can be maintained and where necessary library and laboratory facilities exist.

(3) Maintaining plant and crop collections at the Central and Provincial centres of Agricultural research.

and safflower. In regard to linseed, besides hybrid 1150, there were a number of other strains which were found quite satisfactory and suitable to the conditions of the different tracts in the provinces. Their main problem with reference to linseed was rust and that had been solved by evolving types 1150, 1193 and 1206 which were satisfactory from the standpoint of rust-resistance. As regards groundnuts, as far as the requirements of the province were concerned, they recommended an early type which could be harvested before *rabi* sowings. They had also been able to get three types which, if sown by the middle of June could be harvested by the end of September and then they got full one month for the preparation of field for *rabi* sowings. The type Nos. 2523, 2518, which had been evolved, could be satisfactorily taken up by the cultivators without sacrificing their *rabi* crop. Regarding mustard, the principal problem was the attack of Aphis. They grew three species, *viz.* *Brassica campestris*, *Brassica napus* and *Brassica juncea*. The attack of aphis considerably varied in these three species, *i.e.*, most in *napus* and least in *junceas* They had evolve a type from *Brassica juncea* which was hardy and the attack of aphis on it was practically negligible. They had now got resistant types of *Brassica juncea* 2, 3, 9 and 11 for distribution. Another important point in the selection of mustard types, was the iodine value. The trade has laid down certain specifications regarding this value. Taking that factor also into consideration they had evolved these types which were found to be quite satisfactory. Considerable number of types of *til* had also been distributed. Millets are another important crop of the province and they had evolved types 8A and 8B which are in the process of distribution. *Bajri* and smaller millets which formed suitable food crops of the Kumaun hills had also been taken up. Amongst pulses, *arhar* was the principal crop and the chief problem associated with it was frost and wilt. They had evolved types which were early and which could be harvested before the onset of frost. He agreed with Mr. Thadani that there should be no centralisation of breeding work. It should, on the other hand, be extended to different centres to enable workers to evolve varieties to suit the local conditions.

The types produced in different provinces were not found suitable for the United Provinces. As a matter of fact the types evolved in the United Provinces itself did not suit the several tracts in the Province. He stressed on the point that there should be more co-ordination and elimination of duplication and overlapping. He suggested the appointment of small

committees which could look after groups of crops like oil-seeds, millets and pulses.

Mr. Jenkins referred to the following portion in Mr. Charley's note :—

> "Simple reaping or heading machines for *jowar* and wheat, a cotton planter which will deal successfully with the untreated fuzzy seed, a paddy transplanter, a stone-gathering rake for the clearing of stony fields and a light reversible disc plough are other problems that might well repay much study and experiment."

and said that besides evolving varieties with naked seed instances could be multiplied by which a plant breeder could greatly help other allied sciences. There is a need of a cotton plant bolls which would open out readily and of a wheat which would not shed readily after ripening. Protection of plants against insect attack was also an important aspect of breeding and production of resistant types in sugarcane and other crops was being found very helpful.

Mr. Sawhney said that Dr. Pal had recommended that wheat breeding work should be centralised in two or three main stations. With cotton it has been observed that not only the varieties imported from neighbouring provinces have done badly in Hyderabad but even improved strains produced at the Research Station have sometimes failed to give equally good results when grown 50 to 60 miles away from it. Mr. Ramiah also points out in his paper that "the great range of agricultural and climatic conditions under which a particular crop is grown in different parts of the country has resulted in special local adaptations and it is more an exception than a rule that a variety doing well in one tract gives a satisfactory crop in a different tract". The establishment of additional plant breeding stations and not the centralisation of breeding work seems necessary.

As regards the survey of breeding material and botanical crop composition it may be mentioned that a comprehensive survey of the cotton crop of Hyderabad State has been completed recently. It has been observed that whereas in the northern districts *rosea* type forms the bulk of the crop, in the southern districts of Raichur and Gulbarga, *Cutchica* type (with white flowers and broad lobed leaves) is the dominant component. The seed in both instances emanated originally from a common source, but during the course of cultivation

rosea has become dominant in the north and *Cutchica* has survived in greater numbers in the south.

Dr. Burns, in presenting Mr. Ramiah's paper, drew attention to the method of letting natural selection play its part in the F2 and F3 generations of crosses. In a cotton cross made four years ago in Hyderabad, the first three generations have been grown without making selections in the orthodox way. As a result, the fourth generation now contains a large number of higher valuable types which might possibly have been discarded if the orthodox method of study had been followed. It also appears that this method is capable of giving desired results much quicker than the usual methed in use so far.

Mr. Stewart, in speaking of the rapid multiplication of the seed of improved strains of wheat, mentioned the device of taking two crops of an improved type in one year, by growing it first in the hills and then later in the season in the plains. In Hyderabad it was found last year that an improved strain of *Kharif* cotton could also be grown on irrigation in the *rabi* season. Use will be made of this fact in the quick multiplication of the pure seed of this strain.

Mr. Jenkins had drawn attention to the point raised by Mr. Charley that "plant breeders, in the development of new varieties might bear in mind the problems that they might be brewing for the Agricultural Engineer". It seems that it is not enough for the plant-breeder to produce a high yielding type. He should have a good knowledge of the agricultural and commercial conditions which will apply to his new strains. The response of new types to insect pests and diseases also has to be borne in mind.

Finally, *Rai Sahib Sawhney* said he would mention the question of improving a pure line strain by further selection. As pointed out by Dr. Burns, it appears unlikely that continued selection in a strain fixed for a given character will produce further improvement in that particular character. Further selection, in such strains should aim at the improvement of characters which are *not fixed*.

Mr. D. R. Sethi said that it would be difficult from the administrative point of view to have many breeding stations in a province, but what was wanted was several testing stations.

Mr. Roberts suggested that two practical points deserved the attention of the plant breeder, viz., that the cotton plant

in Sind should hold its *kapas* and not allow it to drop. It was difficult to pick it up from the ground for want of labour and it also contained leaf impurities and the second thing was to produce a variety of cotton which contained a higher percentage of lint to seed in the *kapas*. This would ensure the co-operation of factory owners who had much influence on the seed sown by zamindars.

The Chairman said that in the earlier part of discussion some mention was made of cytology and the application of genetical theory to plant-breeding. In that connection he drew the attention of the Board to Sir John Russell's report where emphasis was laid on the distinction between plant-breeding and plant-genetics and the necessity emphasised of every plant breeder having a sound knowledge of cytology and genetics as one of his qualifications. That did not mean that every plant-breeder need undertake experimental work in either cytology or genetics He suggested that plant-breeders should cultivate acquaintance of the Indian universities to seek their assistance if there was point in cytology to be cleared up. In regard to advances in genetical theory whilst it was clear that there must be a multiplication of plant-breeding centres in India, it was very doubtful whether they need have more than one or two centres for work on fundamental plant genetics and he thought that part of the work could be centralized.

Dr. Burns observed that the debate clearly showed that plant-breeding was still an art and not a science. He moved the following resolution for the consideration of the Board :—

The Board recommends that plant-breeders should in the course of their work attempt a study of genetical variability with the objects of (1) cataloguing the characters available for use in planning new crop types; (2) building up a picture of the genetical composition of the species.

Proceeding, he said that more attention should be given to the study of genetic variability and that the resolution did not run counter to what had already been said on the necessity of centralizing genetical research in one or two places because the raw material for that research must come from the day to day work of the plant-breeder in the field. Two committees were recently set up by the Imperial Council of Agricultural

so far as the Punjab was concerned the conventional figure of 1 lb. was totally inadequate and actually tbe figure was 3 lbs. per head.

As to the revival of the River and Rail Borne Statistics, Mr. Stewart remarked that it was regrettable that it took ten years to get this publication produced once more. Since 1933 it had again been published but there was a gap of ten years of valuable information which could never be filled.

As regards random selection for crop-cutting experiments, he was not aware of the system prevailing in other provinces, but in the Punjab they were still endeavouring to find an average field in an average village.

In regard to present day publications, he said that there were two main and important all-India *annual* publications of Agricultural statistics: one was called *Agricultural Statistics of India*. It was a collection of annual data and did not contain forecasts or other matters of that nature. His main criticism regarding this publication was its late production. The latest edition dealing with figures for 1933-34 reached him only in March 1936, *i.e.*, 2½ years after tbe period covered by the report. This publication contained a great deal of very valuable information which one was constantlv looking for and he felt very strongly that some effect should be made to hasten the publication. As to the matter which was contained in the report. it was only when one had leisure time or staff that one could find out its merits and its defects. One matter came to his notice verv recently, when he was dealing with harvest prices in the Punjab. It was in connection with the table in the publication giving figures for the provincial harvest prices of the principal crops. In checking up the Punjab figures he found that the provincial figure was made up simply by an arithmetical average of all the district figures. Now there were many districts in the province in which certain of the crops were of very little importance and he felt, when dealing with this matter. that instead of an arithmetical average it would be much better to give a weighted average. It would give a much truer picture of actual conditions. That and other matters like it, however, were points which one could only detect and on which one could only make suggestions if one had leisure or extra staff to do it. Directors of Agriculture had not much time to devote to such work unless they were investigating some particular problem, and he, therefore, emphasised the necessity for providing some special staff for helping to deal with the collection and checking of statistics.

The other important *annual* publication was *Estimates of Area and Yield of Principal Crops in India.* As its name implied, it was purely made up of estimates. The yield figures were made up by multiplying the estimated area of a crop by the normal or standard yield for that crop in the province concerned and he added that he had very little faith in the figures for normal or standards yields. Referring to Mr. Livingstone's note in which he had made certain suggestions as to the alterations that might be made in the publication. he said that in addition to the estimates for the latest year the estimates for the previous nine years were also included. Mr. Livingstone had suggested that instead of estimates, the actuals might be put in as actuals might be available by then. He personally saw no objection to this, except that the title of the publication would no longer be quite correct. Further referring to Mr. Livingstone's suggestion that fuller figures should be included for rice, he said that the Punjab figures and those for certain states in Madras were not included at the present time and in each of these places rice covered an area of somewhere round one million acres The area was, therefore, surely adequate for inclusion. He would strongly support this suggestion and requested the Board to recommend that estimates regarding rice in the Punjab and in the States concerned in Madras should be included in future.

Regarding the *monthly* publications, the principal ones were two in number:—(1) *The Sea-borne Trade and Navigation of British India,* on which he had no comments to make; and (2) *The Rail and River-borne Trade of India.* The particular point he wished to make in connection with the statistics for the rail and river-borne trade of India was that it was not comprehensive enough at the present time. In 1924 one of the recommendations of the Board, or a reference to that effect, was that road transport was becoming important, but nothing, had so far been done in that connection. In the meantime the whole position regarding road-transport had changed and in the Punjab, at any rate, road-transport of agricultural commodities was a very important matter, particularly in regard to transport of vegetables and fruit. He quoted one instance where cottons was being transported from Okara—a place some eighty miles from Lahore—to as far away as Gwalior, by road, and there might be other instances which had not yet come to his notice. He said that his marketing section recently came to the conclusion that of the inter-provincial traffic in agricultural commodities between the Punjab and

outside provinces and States, thirty per cent., of the total imports and exports were by road. The actual provincial figures obtained for certain commodities disclosed that of the total imports and exports of hides and skins 20 per cent. were were by road: of linseed, groundnuts and ground-nut oil forty per cent., of fruit thirty-one per cent. and of cattle ninety-one per cent. There was a very heavy export of cattle northwards, in particular towards the Frontier. The movements of cattle by rail had been recorded in this publication since April last, but according to the Punjab figures the traffic in cattle by rail was only nine per cent. of the total export or import of cattle between the Punjab and outside, while ninety-one per cent. was by road In view of these facts and figures, they, in the Punjab, felt that a strong effort should be made to secure the collection of data for road-borne trade and its inclusion in this publication.

Then there were two *quinquennial* publications to which he wished to make a reference. The first was the *Live-stock Statistics*. In that connection he pointed out the danger of publishing what to his mind were undigested data, and referred to a table in the end of the publication which dealt with agricultural stock other than live-stock and included such things as ploughs, carts, boats, sugar-cane crushers, tractors, oil-engines for tube-wells and so on. Now under the head 'tractors' it would be found that in the Punjab, in 1935, when the publication was last issued, there were supposed to be 2,133, but those who were familiar with present day conditions in the Punjab knew that if there were 2,133 tractors in 1935, most of them were not used for agricultural purposes. They might have been used for levelling roads or driving stationary machinery. A certain Marketing Officer, not long ago, while trying to work out the ratio between the number of bullocks and the area of cultivated land in the Punjab turned up these figures and said that as there were 2,133 tractors, these were equivalent to so many additional bullocks which must be taken into account in calculating the ratio of bullocks to cultivated land. But in fact the tractors which existed then were not being used for agricultural purposes and it was, therefore, very unsafe to publish simply a statement that there were so many tractors giving the impression possibly to those who did not know local conditions that they were used for agricultural purposes. It would seem desirable, if such information was given to include in the narrative somewhere a word as to the purpose for which those tractors were used.

He then referred to the *Quinquennial Report of the Average Yield per acre of the Principal Crops in India,* which, he believed, was compiled from the statements and data for the normal yields of the principal crops in the various provinces. He doubted very much whether the information was of any real value. He said that in his remarks he was referring constantly to the Punjab and Punjab figures. By that he did not wish to point out specially the merits or defects of the Punjab. But it happened to be the province about which he had most detailed information, and he believed that it was fairly representative of the conditions in other provinces.

As reasons for his statement that he put very little value in these publications, he gave the following two instances. If one looks at the figures, he will find that the Punjab provincial average outturn of cotton for the last quinquennium for which figures were published, was 4.63 maunds of *kapas* per acre. Recently he had analysed the position very carefully in connection with the cotton crop. It was the one crop where actual figures were provided in the ginning and pressing returns which acted as a check on the provincial forecasts. He had referred in some detail to the results he had found in the note placed by him before the Board. He did not want to repeat what was already stated in the note, but would content himself by saying that instead of an average outturn of *kapas* of 4.63 maunds per acre they found that during the quinquennium which had just been completed the average outturn which actually passed through the ginning and the pressing factories was 6·46 maunds of *Kapas* per acre for the province as a whole whether the cotton was irrigated or un-irrigated, or of *desi* or American variety. If to that figure was added what was found to represent the village consumption of cotton a final outturn of 7·6 maunds of *Kapas* per acre was got against 4.63 which this publication gave. Mr Stewart believed that the figures for other provinces were not likely to be any nearer the mark than in the Punjab.

was found that for irrigated wheat in the Punjab—he dealt with irrigated figures only because they were less liable to fluctuations from climate and season than un-irrigated—in the quinquennium ending 1921-22, the yield was 1020 lbs. per acre. In the next quinquennium which ended 1926-27 the figure had fallen to 997 lbs. and in the most recent quinquennium which had been published in 1931-32 the yield stood at only 967 lbs. Hence although they were satisfied that the improved seed gave better outturns than the indigenous, over the period of nearly twenty-five years during which they had been distributing improved wheat the result appeared to be that the average outturn of wheat in the province had actually fallen from 1,020 lbs. to 967 lbs.

Again, taking sugarcane, the Department had been doing a good deal in the introduction of improved Coimbatore varieties and were quite satisfied from their own experiments and from results on reliable large cultivators' holdings, that the outturns got were very considerably in excess of those got from the old indigenous *Katha* varieties grown in this province. Now if statistics were consulted for the quinquennium 1921-22 the normal yield of *gur* in the Punjab would be found to be 2,344 lbs. per acre. Today it was 2,046 lbs., so that in spite of the fact that they had a very large area under improved sugarcane, their yield, according to these figures, had fallen by about 300 lbs. of *gur* per acre. These figures certainly did not represent actual facts and it was for this reason that he said that very little reliance, at any rate so far as the Punjab was concerned, could be placed on this publication. He would like to know very much whether other provinces had found a similar state of affairs.

In regard to remedying the defects pointed out by him, Mr. Stewart said that the figures of normal or standard yield which were published had a definite influence on the mind of the subordinate official who was connected with the preparation of crop forecasts. He strongly doubted that if, according to the published data and commonly accepted fact, the average yield was—say—five maunds of *kapas* per acre, there was little hope of getting an estimate considerably in excess of that figure even though that estimate was justified. In the preparation of forecasts in this province, the revenue and the agricultural staffs made separate estimates. On the revenue side they began with the village Patwari who passed on the figures for checking by the Tahsildar. From him they went to the sub-divisional officers who sent them to the Deputy

Commissioner. The Deputy Commissioner then passed them on to the Director of Agriculture or the Director of Land Records as the case may be. On the agricultural side the agricultural assistant prepared the figures and passed them on to the Extra Assistant Director of Agriculture who in turn submitted them to the Deputy Director of Agriculture. The Deputy Director of Agriculture, with any amendments he considered necessary, passed them on to the Director. He said that the Director thus had then two sets of figures to assist him in framing the forecasts of each of the principal crops, —the figures given to him by the revenue staff and those by his own staff. Unfortunately a very wide divergence was to be found between those two figures. As lately as last night he was preparing his forecasts for cotton. For some districts he was given an average outturn from the Revenue Department, of 2 1/3 maunds per acre. His own staff gave $5\frac{1}{2}$ maunds per acre. Similarly the position was reversed in some other cases. Having, after including the normal standard yield, such a diversity of figures it was most difficult for the Director of Agriculture to arrive at a correct estimate of the crop. In the later forecasts, however, some actual figures are available as a guide, *i.e.* the ginning and pressing returns, the results of experiments on farms and the results of the crop-cutting experiments. Whatever hope existed for accuracy in forecasts, it existed in cotton, because of the existence of data for production as shown by the ginning and pressing returns. There is no such check on other crops. One had only to rely on experimental results or on reliable big cultivators. He found that if he had to rely entirely on the figures sent to him by the Revenue Staff when framing crop-forecasts, his forecasts would be very wide of the mark. He did not know what action could be taken to improve those conditions. Regarding the cotton forecasts he had himself addressed all Deputy Commissioners on more than one occasion. On another occasion he had referred the matter also to Government who addressed the Deputy Commissioners. Yet one found that estimates, even if maxima were taken, were very far below the actual crop.

Referring to the standard or normal yields and how they were obtainable, Mr. Stewart said that crop-cutting experiments were being carried out both by the Revenue and the agricultural departments in the Punjab. In 1923 Government decided to greatly increase the number of crop-cutting experiments in order to get more reliable data if

The *Chairman* said that he would like to make one or two remarks. In the first place, the Government of India were at present reorganising their Statistical Department. It was impossible to condense in a resolution or a series of resolutions all the points it was desired to bring to the notice of the Board. He, therefore, proposed to forward a full record of the proceedings to the Director-General of Commercial Intelligence and Statistics through appropriate channels. He would, therefore, ask all speakers to concentrate on main points that were to be brought out. Secondly, as Mr. Stewart's concluding remarks showed, everyone realised that the capacity of the Central Statistical Department to produce statistics would depend almost entirely on the character of the statistics sent up from the provinces and States—both on their character and on their promptitude. He did not know whether the Director-General of Commercial Intelligence and Statistics was receiving all the information the provinces had. It should be borne in mind that primary statistics came from provincial sources and the Director-General of Commercial Intelligence and Statistics was helpless if they were imperfect or delayed. There were certain possibilities of improving the Central Statistical Organisation but unless the primary statistics were reliable they would not get very much further He commended these points for the consideration of the Board.

He then invited Mr Jenkins to summarise his own note and that of Mr. Ambekar

Mr. Jenkins said that Mr Stewart had dealt with the subject so exhaustively that there was very little for him to say With regard to the question of staff with which he finished his remarks, he entirely agreed with Mr Stewart that some increase in this direction was necessary not only to improve the compilation and presentation of statistics but also for the very important work of looking through past years' statistics and utilising them to obtain information which was inaccurate and insufficient today. With regard to crop-forecasting he entirely agreed with Mr. Stewart's remarks

Regarding 'anna valuation' returns which were received from Revenue officers in the districts, he thought that the Collectors or District Magistrates did not consider them sufficiently worth their attention The Government of Bombay had issued orders to collectors with a view to improving the 'anna valuation of crops' in the districts suggesting that they

should also offer their personal views when submitting figures. He thought efforts must be made to impress upon the District Magistrates of the importance of these figures. With the growing interest that trade and cultivators were taking in this question the importance of the supply of accurate statistics could not be over-emphasised. In the Bombay Presidency they were fortunate in having a scheme which was devoted entirely to the improvement of their cotton statistics. It was financed by the Indian Central Cotton Committee. It had not yet been completed but one could say without any degree of uncertainty that the information already obtained had been of very great value and that the Officer in charge of the scheme had detected many sources of error—some small, some exceedingly large, which without such an investigation would have gone undetected and the errors resulting therefrom would have been continued. That Officer had submitted a note proposing an extension of such an investigation to cover an all-India crop improvement forecast scheme. Mr. Jenkins, continuing, said that he was not in agreement with all his proposals but he thought there was some scope for general improvement and standardisation of the methods of working out statistics in different provinces and a preliminary examination on an all-India basis would be a useful step and likely to produce good results.

He also agreed with Mr Stewart regarding standard normal yield figures They were juggled with whenever opportunity arose Experience had shown that they were often entirely unreliable With regard to the note submitted, it was merely a statement of work done in the Director of Agriculture's office and indicated the very large amount of work on statistics which was required. With regard to crop-cutting experiments, it would be interesting to hear from Prof. Mahalanobis the numbers which he considered necessary for an area of cotton such as described by Mr Stewart. He felt that the results of such an enquiry would bring home once for all the futility of relying alone on crop-cutting experiments done annually on a sufficiently large scale to enable accurate figures of standard normal yield for all crops to be arrived at within reasonable cost Some other method of examination of yields obtained on Government farms and in the districts or other methods, as suggested by Dr. Burns, would be necessary. Crop-cutting experiments, to be effective as the sole means of determining these two factors, would require to be done on a much more extensive scale than the Agricultural Department

and the Revenue Department could cope with under existing conditions of staff and finance.

The Chairman then invited Dr. Burns to speak on Rao Bahadur Vaidyanathan's note.

Dr. Burns said that he would like to insist on one point only, *i.e.*, the need to forge a weapon before it was used, in other words, to develop a scientifically sound method of crop-cutting experiments before anything else was done. He thought money would be well spent on establishing staff where it did not exist for such experiments. He understood from Prof. Mahalanobis that it was not difficult to devise an experimental scheme to see whether the number of samples taken in a particular manner would give results of sufficient accuracy. This was his main reason why he did not think any hard and fast rule should be laid down for crop-cutting experiments until a sound theory was evolved.

Recommendations made in *Rao Bahadur Vaidyanathan's* note, *viz.*, "cuttings can best be done by marking along a diagonal of the field as many points as the number of units necessary at equal pacings between point and point, and cutting the crop at each point an area covered by a circular hoop" could not be made at this stage. "Condition-factor" was again a nuisance and would have to be tackled separately. The only way to do that was through a system of weekly or monthly reports sent by trained observers. That again was a counsel of perfection at the moment.

Mr. Thomson (Senior Marketing Officer) said that Mr. Stewart had already referred to Mr. Livingstone's note (Appendix VI), in his introductory speech and he did not think there was anything he could possibly add to what he had already said. One of the great difficulties they had encountered in their marketing work was not only the defects in the primary data but also defects in the presentation of whatever data was available. They took as an example the two principal publications in which crop statistics are given, *viz.*, (1) *Estimates of Area and Yield of Principal Crops in India* and (2) *The Agricultural Statistics of India* and they had quoted six instances in which improvement could be made. The first three referred to general matters and the last three to rice. As regards rice, the discrepancy between the actual position and the conventional figure was not very large. If he might quote the instance of linseed, the difference between the conventional forecast figures and the actual figure

was twenty per cent. The yield of linseed in India was regarded by most as 400,000 tons. In fact the average crop had been 461,000 tons. This was not generally apparent in the mode of presentation of statistics at present.

Prof. Mahalanobis said that the comprehensive review given by Mr. Stewart was most useful. In April 1937 in Calcutta under the auspices of the Indian Statistical Institute the question of improving the official statistical publications was taken up. The Director of Commercial Intelligence and Statistics and representatives of the Bengal Chamber of Commerce and other Chambers of Commerce were present. The Director General of Commercial Intelligence and Statistics emphasised the need of accelerating the supply of provincial statistics He pointed out that his office was chiefly concerned with the compilation and editing of whatever material was obtained from the provinces. That point had to be borne in mind in any future schemes. As regards normal yield, he stated that he had had occasions to examine the actual estimates in certain districts in Bombay, Central Provinces and a good many places in Bengal. For each district they had an average in terms of the normal by so many "annas" which was converted into percentage for each year In this way they got not only one figure but quite a large number of figures For twenty years they had something of the order of 400 different estimates in terms of the normal yield. If the normal was anything approaching normal, one hundred was to be the actual average As a matter of fact they found that in anything examined the actual average of the estimates seldom exceeded eighty and in many cases it was sixty. In other words, the normal was not the normal as it was ordinarily understood but something like the maximum crop which the cultivator was likely to get once in twenty or thirty years In other words, in estimating by the "anna system" the reporter was thinking of what by very good fortune the cultivator might get once in his life time and on that basis put the actual estimate On the question of crop-cutting experiments to which Dr Burns had drawn the attention of the Board, he had two suggestions to make. A month and a half ago he had occasion to look into a United Provinces scheme and to discuss what could be done in the way of improving the technique of crop-cutting experiments. His own view was definitely in favour of some kind of random selection of fields. As regards the number, he thought 500 was quite a good number and with careful work he did not

think why accurate figures could not be got. If the crop-cutting experiments differed on an average by 100 even then with 500, an accuracy of the order of five per cent. or less could be got for the whole of the province. It might be a good deal more than that. Under four different conditions, *i.e.*, irrigated, non-irrigated, *desi* and improved types they might go to between five and ten per cent. He did not think the fault was so much with the numbers. It might be necessary to increase the number to 600 or 1,000, but 500 was quite a good number. A method by which number of samples could be reduced was that of zoned random sampling. By this method each sub-division, district or province could be stratified, *i.e.*, split up into definite zones representing particular soils, climate, etc., so that each zone could be homogenous for a particular set of conditions. In such uniform areas the number of samples could be reduced as there was no necessity of taking a large number of samples in homogeneous areas, but it required a certain amount of experimentation. Prof. Mahalanobis further explained that he would be quite content as a statistician to accept as a basis the results of an experiment where 500 samples were distributed in the selected zones in each province. In an area which was fairly homogenous we should be content with relatively fewer samples and reserve the rest for some other sub-division where conditions varied a great deal. It was worth spending some time and thought on these things.

Prof. Mahalanobis stressed on the necessity of honest work in the field. By adopting the method of leaving twenty samples in two batches of ten each in the same area by two different sets of workers it was possible to check the accuracy of the work done. If the variations between the two results were not great, the average of the two might be taken as the standard for a particular area. But if the variations were great, it should be understood that there was something wrong somewhere. This type of check might be called interpenetrating random sampling.

Mr. Richards said that in the United Provinces the original attempt to improve crop-cutting experiments adopted by Mr. Allan was now in its third year. The data obtained in 1935-36 were sent to Rothamsted and Mr. Yates expressed the opinion that as far as the farms were concerned the experiments were better conducted and the results obtained were satisfactory. Random sampling irrespective of the condition of the crop was an absolute necessity. This had

not been rigidly observed in the United Provinces but the orders regarding this would be changed this year. Crop cutting, however, was not yet a sure basis for estimating standard yields. Eye estimation would still be needed. This should be done by experienced and reliable representatives of the departments or of the general public. The staff required for crop-cutting experiments on proper lines was enormous. He had recently submitted a proposal to the United Provinces Government for crop-cutting experiments on one crop of sugarcane at a cost of about Rs. 1½ lakhs per annum. He considered that that expenditure was at present far beyond the capacities of the Provincial Governments to accept, but it was important to convince them that such work was necessary. He supported the suggestion that the Board should impress upon the Local Governments the necessity for viewing the crop-cutting experiments and crop estimate procedure as much more important than most of them did at present.

Prof. Mahalanobis said that 500 samples would be adequate to give fairly good results but there was need for experimental work first, and that the problem should be viewed from an all-India standpoint. A beginning should be made without delay and he suggested that the Directors of Agriculture should set apart 5 per cent of the amount spent every year by them for crop-cutting expenditure towards meeting the expenditure on the experimental work suggested by him.

The *Chairman* explained the point of view of Professor Mahalanobis and said that 500 samples were intended for a homogenous area and not for all the different types of soils, with varying irrigation and climatic conditions. There were several types of irrigations such as by the canal, tube-well, etc. The 500 samples were intended for one particular homogenous area. Further the area selected for random samples should be typical From experience of the United Provinces he could say that the crops near a village were generally good and those on the outskirts of the village were generally poor and when selecting plots for crop-cutting experiments care should be taken to eliminate these two extremes.

Mr. Stewart moved the following resolution which was seconded by Mr. Jenkins :—

"The Crops and Soils Wing desire again to emphasise the importance of adequate statistics of agricultural production as a basis for the work of the agricultural departments on the improvement of crop production. The extent to which

agricultural departments are responsible for such statistics varies in different provinces and states but in all cases other departments are closely concerned. The Board, however, suggests for the consideration of the authorities concerned that agricultural departments should be placed in a position to make a closer study of this problem.

The Board desires that a record of the discussion be submitted to the Government of India, Provincial and State Governments and the Imperial Council of Agricultural Research for consideration."

Rao Bahadur Ramaswami Sivan agreed with the last portion of the resolution, namely, the need for the officers of the Agricultural Department coming in the preparation of these statistics. He suggested that the Directors of Agriculture should, with the help of their agricultural demonstrators, find out whether certain areas termed as "culturable waste' by the Tehsildars and Collectors, were really cultivable. He did not. however, suggest that a special staff should be maintained for it. All that he wanted was that the Directors of Agriculture might issue an order to the Agricultural Subordinates to collect this information when they went round the villages on tour. He then emphasised the importance of bringing more and more of the present waste lands under plough.

The *Chairman* said that the Board could not take up the question of the utilisation of waste lands at present. The Standing Fodder and Grazing Committee of the Imperial Council of Agricultural Research had taken up the question of utilization of waste lands and its improvement for grazing and it was very likely that the Board would have an opportunity for full discussion of the subject.

The resolution was put to vote and carried.

Mr. Rama Reddi enquired whether it was the intention of the Board that the Directors of Agriculture should be responsible for agricultural statistics. He wanted to make this point clear because in the Madras Presidency at any rate, this work was being carried out by the Industries Department.

The *Chairman* said that this was entirely within the competency of the Provincial Government. *Mr. Roberts* said that the actual yields could be obtained by other methods as well as by crop-cutting experiments, *e.g.*, of cotton through ginning and pressing factories—crop-cutting would involve long waiting. The difficulty was of obtaining standard

yields because the land revenue and other taxes were based on this yield and the farmers were naturally anxious to make that figure as low as possible. It was in the interest of the country that actual figures should be obtained.

Subject III.—A review of work on the improvement of bullock-drawn implements, with suggestions for the future.

Mr. Charley in introducing the subject said that he had very little to add to his note (Appendix VII) which had been circulated to the members of the Board. In the first few pages he had attempted to give a very brief outline of the early work on implements. As he had mentioned in the note, he was of the opinion that the implement problem had not been tackled from the right angle. Too much time had been devoted to attempts at introducing elaborate, horse drawn, western implements, working from the top downwards rather than from the bottom upwards, from the existing indigenous implements towards better forms. Secondly, he pointed out the notable achievement of the early workers in the successful introduction of the modern, western, mouldboard plough. This was contradictory to his remarks regarding the wrong approach to the problem, but happened to be one of the few exceptions. Thirdly, there was the birth of the plough making industry in India, and its rise to a very important position Regarding this point he referred to page 278 of his note

The present position, he said, was characterised by a somewhat greater appreciation in all quarters of the importance of agricultural engineering to Indian Agriculture and a better attention to the subject on the part of Agricultural Departments, by the services of the Imperial Council of Agricultural Research in various directions, and by the marked improvement in the quality and prestige of Indian made implements, all attributable in some way to the valuable recommendations of the Royal Commission of 1926. The future appeared brighter than it had ever been, but the path of progress was still beset with many difficulties.

On page 279, he had said something regarding the pros and cons of the modern, inversion, mouldboard plough. There was no doubt that the utility of the modern, inversion plough was very closely linked up with soil fertility.

On page 279, he had referred to the way in which plant breeders and others might work in collaboration with the agricultural engineer, and gave several examples in which such collaboration could be effected.

On pages 280 and 281, a brief reference was made to the various types of improved implements, including a bund forming implement which had been designed to replace the laborious and costly hand tool method of bunding. In addition to the bunding of fields for irrigation, it had found a valuable application in dry farming tracts for moisture conservation work. The new system of basin listing was proving most effective in moisture conservation and erosion control in America where it had been developed, and could be applied with great advantage in India. He had recently designed a simple basin furrowing implement for bullock draught and it was working very well.

In the recent competition inaugurated by the Imperial Council of Agricultural Research for improvements in tillage implements, the designs submitted displayed a marked tendency to depart too far from conventional lines into the realm of fantastic, impracticable and "gadget" features. In the design of implements, the guiding principles should be extreme simplicity, complete practicability and standard, well approved practice. In manufacture the pressing need was for improved quality and finish, standardisation and mass production.

On page 281, he had said something about single and multiple purpose implements. There was no doubt that the cultivator could not afford to have a wide range of implements but he advised that, as far as possible, the tendency should be towards single purpose implements rather than towards dual or multi-purpose implements, which were usually inefficient.

As regards yoking and hitching (page 281), the trouble was the steep draught line. The big vertical component of the pull tended to lift the implement out of the ground. There seemed to be no practicable solution. Regarding yokes, there had been various attempts to improve on the common wooden yoke. An improved system of yoking in use in Madras employed a broad leather neck band with traces coupled to a spreader bar at the rear. There was a broad contact area on the neck and galls were prevented.

Mr Charley then explained the suggestions made by him on pages 282 to 285 of his note. The first suggestion related to the manufacture of implements. The greatest obstacle to their wider adoption was their price, and there

was considerable prospect of its reduction by large scale production. Eight or ten years ago Kirloskars' cast, turnwrest ploughs were priced about Rs. 80 Now they were down to about Rs. 30. A light Meston type plough was capable of very cheap production. Though it was about Rs. 9 only a few years ago, it was now down to Rs. 3-12-0, and could be reduced to Rs. 2 by mass production. Each Province was developing its own range of implements. The result was that a large number of types were being produced for a few set conditions. There should be co-ordination of the work in the various Provinces and standardisation on a few basic types. We must retain only the very best types and fix on the very minimum number that will meet most requirements and standardise upon them. For example, there were about a dozen types of turnwrest ploughs offered by one Indian maker. Three or four would be enough In Madras Presidency there were about thirty distinct forms of cane-cutting knives where two or three would suffice. The village manufacturer should be eliminated as it was impossible to build up a supply of efficient, standardised implements on a basis of village manufacture.

There was room for improvement in the matter of publications. In writing his note he had had to spend many hours in the Library at Coimbatore to confirm what had been done in other Provinces He could discover only scrappy reports and no conclusions. It was almost impossible to get a correct idea of what was going on in India in implement work. With regard to leaflets and bulletins, they were not striking the right note We had modelled our publications on conservative western lines which were quite unfitted to the standards of intelligence and education of the Indian farmer, and we needed to adopt a much simpler and more attractive style. Much more use should be made of pictorial illustration. Our message should be conveyed, as far as possible, by simple, forceful and attractive drawings and action photographs.

His next suggestion related to the training of agricultural students—those whose business it was later on, as demonstrators, to instruct and educate the farmer in the advantages and use of improved implements. He found demonstrators in Madras knew very very little about modern implements and machines and agricultural engineering generally. They had never been taught it. He suspected that what prevailed in Madras might be prevailing in other Provinces. Many demonstrators in Madras could not even name the parts of implements or describe their functions correctly, and when they

take the initiative and start experiments under different conditions throughout India in co-operation with the local departments of Agriculture.

Mr. Johnston said that the Royal Commission on Agriculture has observed that no experimental work had been done on the use of furrow turning ploughs in India to find out whether they were economically advantageous or not. On going through the records he found that some work had been done at Cawnpore and Lyallpur. The experiments carried out at Lyallpur did not show any increase in yield, whereas the experiments conducted at Cawnpore showed that there was a distinct increase. The difference in these results might be due to climatic and other conditions. Mr. Johnston said that in many parts of India, particularly in the dry tracts, there was not the same need for furrow turning ploughs as in European countries. In tracts with a low rainfall where grass and weeds were scarce, a cultivating implement which stirred up the soil served the purpose of producing a good tilth equally as well as a furrow turning plough. From experiments carried out at Lyallpur it was found that the use of improved implements caused little or no increase in crop yields but that a twenty per cent. saving in time and labour resulted from their use. If zamindars have time and labour to spare they can obtain as good yields by the use of indigenous implements as with improved implements, provided the land is not too dirty and they are willing to carry out the requisite number of operations to produce a good tilth. The experiments referred to here were carried out in the canal colonies of the Punjab but as conditions varied from one tract to another and from Province to Province he stressed the importance of conducting experiments in each Province on the subject.

Before the meeting terminated, the *Chairman* announced that the Board would sit at 10 A.M., tomorrow and that Dr Burns would preside over the deliberations of the Board.

Mr. Roberts proposed a vote of thanks to Sir Bryce Burt. It was seconded by Rao Bahadur Viswanath and carried unanimously by the Board.

The Board adjourned at 12-45 P.M. to meet again at 10 A.M., on 9th December.

Proceedings.

Fourth day.

The meeting started at 10-05 A.M.

Rao Sahib Thadani said that if it was possible to get a review of the improved implements in use in all provinces for various purposes, it would considerably help in finding out what use could be made of them in other parts of India. He suggested the preparation of a list of that sort. In Sind, any implement which was costly or complicated in design or required greater draught of cattle did not find favour with the cultivators. The farmers at the same time did not want many implements for rice. The department had now introduced a plough which had become the standard plough in the province especially on the left bank in the areas where cotton and wheat were grown. It came into use early in 1907 in Thar Parker district; that was now the only implement in use for ploughing, interculturing and all kinds of operations requiring tilth. Its pattern was that of Egyptian plough, it was called Sirkar plough, costing about five rupees. Another implement which they found to be of use was a kind of seed-drill. At present they were using the Lyallpur pattern of seed-drill. Another implement which had been recently designed was known as Jenkins Clod Crusher. This implement was devised to break clods in stiff lands, and in the case of large irrigated areas, to retain the moisture in the land by running it over the surface. Its further use had been that of threshing crops like wheat, *juar* and rice. This implement was very popular because of its use for two or three purposes but its cost was rather prohibitive being about Rs 70. They were trying to introduce a co-operative system for wider distribution of such implements. Another implement introduced was the winnowing machine. This implement was very useful for winnowing wheat before the start of the rains. Often for want of a good breeze winnowing was delayed and the crops are damaged by the rains. He had given a list of useful implements in his note and it would be very helpful if similar lists of useful implements were prepared for other provinces.

Mr. Allan said that before he left the Central Provinces he made a close study of ploughs and plough work in India. There appeared to be two questions in ploughing, *i.e.*, (i) of inversion and (ii) of depth. In the case of *Kharif* crops the inversion plough was not useless but it was very expensive

local manufacturer was rather a menace. The ploughs manufactured were never reliable and wore out in about fifty or sixty hours of work. Ransome ploughs lasted two or three times as long, but the trouble was the primary cost, *i.e.*, Rs. 8-8-0. They had arranged with Kirloskars to make the body of the plough and by putting in the Ransome share in the implement the price was reduced to Rs. 5-8-0. The price was also helped to go down by mass production of wooden parts. This could only be done by the fact that they were able to give Messrs. Kirloskar very large order.

Besides the question of cheapening the cost of the plough and standardisation, another important question was of demonstration, which in some cases was extraordinarily bad, partly due to the fact that the demonstrators were not properly trained in the work. A good deal more emphasis should be laid on making these men know their part of the work well. It was however, important that a good deal of incentive and encouragement should be given to the men doing such demonstration. Something in the way of a demonstration fee should always be paid, as that was very helpful in improving the sales of ploughs. His experience in the Central Provinces was that by paying Re. 0-8-0 on every plough to the demonstrator the sale jumped from 2,000 to 6,000 ploughs in one year. He then emphasised the fact that the department must organize a certain amount of service. It was no use selling a plough unless the Department was able to see that it was kept up to the mark as otherwise when things once began to wear the cultivator would dump it into his godown for ever.

To sum up, he said, it was necessary, in order to improve the ploughiog implements, to introduce a cheap and reliablo plough, giving incentive to the party doing demonstration work by paying commission and maintaining service in order to keep up the reputation.

Mr. Wynne Sayer held that the country plough was most suitable for use in a small holding. The reason of the turnover plough being unpopular was not entirely the poor purchasing power of the ryot or the miserable condition of the bullocks but that the cultivator was not convinced of its usefulness. The experience of the cultivator was, and he quite agreed with him there, that by deep ploughing for *rabi* one was liable to lose moisture. The standard rule was to open land deep in the hot weather for *kharif* and to open little and close it as soon as possible when dealing with *rabi* sowiogs. He was of

the opinion that a lot of experiments with regard to ordinary country plough were really inconclusive as along with the *desi* plough deep ploughing was done whenever it was found necessary. They failed to realise that a ryot holding an acre of land gave it a ten inch working with a *kodali* in March or April and this was his deep ploughing—while *rahar* (*Cajanus indicus*) was also a crop which worked the land deeply by reason of its root system—such a man did not want a turn-over plough on his holding and it was only the man with a holding of five acres or so who could utilize iron ploughs.

Further he said that they should find the reason why the ryot at the present moment was so conservative. About ploughs, the fact was that he was absolutely terrified to go outside of what he really did know. Mr. Sayer felt that if the cultivator had a piece of land where he could do experiment and was not dependent entirely for his livelihood on that land he would probably be much less conservative, and if he was convinced of the advantages of the turn-over plough he would take it up. After all he had taken up great many other things, *e.g.*, he took up Coimbatore canes very quickly but he was very nervous of doing something to his land which his forefathers told him was not customary farming practice and until they definitely proved to him that it was sound practice, things would remain as they were In regard to winnowers and other labour saving implements, it is difficult to see much chance for spread of such machines as the labour was extremely cheap.

Mr. Low was in general agreement with Mr Sayer and said that nobody would suggest that improved implements could do the whole job He was of the opinion that the soil turning improved plough could only be used as an adjunct but it could never replace the indigenous ordinary plough It was therefore unwise to dispense with the country plough altogether. From his experience of Cawnpore and elsewhere he could say that locally made *shorees* worked for 20 –48 hours, while the English ones worked for about 200 hours

Khan Bahadur Fateh-ud-din thought that the cultivator in the Punjab is not convinced that if he were to put more money in the purchase of an improved plough he would get equally good service, otherwise he was quite quick in adopting methods and taking on implements which were beneficial to him, *e.g.*, in Jullundhur where holdings were small, being roughly two acres each they had to put all available area under grain crops

and had to economise in fodder. Chaff-cutters were, therefore, commonly in use in that District. It appears therefore that the Department had not yet produced any plough which was efficient for all purposes of the cultivator.

Sardar Harchand Singh (Patiala) said that before evolving a plough they had three points to consider, *i.e.*, (1) it should be cheap, (2) it should be capable of repairs by the ordinary village blacksmith and (3) it should be as efficient as the iron plough and should have no nut and bolt. Such a plough has been invented by them and was exhibited in the Lahore Exhibition by the name of Patiala Plough. The village blacksmith was paid in kind for his contract of repairs during the whole year whether the work was small or large. It therefore suited the cultivator to get all repairs done by the village blacksmith. The cutting point of the iron plough wore out quickly. In his opinion the desi plough could not be replaced altogether. The Patiala plough had a long iron bar which served the purpose of a cutting point. It could be mended locally and could be had for Re. 0-4-0 to Rs. 0-5-0. The Kirloskars supplied them this plough at Rs. 11 f. o. r. Patiala but the arrangement was not satisfactory. His Highness the Maharaja Sahib Bahadur had sanctioned Rs. 25,000 for the distribution of implements among the ryots. There was a proposal to start a workshop, in which this grant is to be invested and certain shares were to be allotted both to the farmers and the firms. The profit from the State share is to go back to the cultivators in the form of cheaper implements. The bullocks were accustomed to draw a plough in which the beam was at a certain angle to their shoulders as in the desi plough and so a plough having these merits would be popular. Also the adjustment should be so simple as to make it go deep or shallow into the soil according to requirements without opening nuts and bolts. They had made that improvement in the Patiala plough. The cultivator should be able to do this adjustment by a piece of wood obtainable from the trees on his fields as was done in the case of desi plough.

Mr. Roberts said that he was particularly interested in Mr. Charley's way of looking at the problem. In the past there had been a tendency to work from the top downwards instead of from the bottom upwards. Most of the earlier recruits to the Agricultural Department started by trying to introduce the English plough or a modification of it instead of by working up from what was already in use in the country and seeing

what improvement could be effected. He suggested that the first duty of each province in this connection should be to have a reliable record of indigenous implements in use and of the places where they were used and if possible to set up some kind of museum. This sort of work was being done in Great Britain in agricultural colleges and a great deal of attention was being paid to the historical aspect of implement improvement. The lack of record of improved implements at provincial agricultural colleges in India was a serious handicap in the way of improving their performances and extension. He had no doubt that this was a counsel of perfection for one or two provinces but taking India, as a whole, this method of approach was the soundest way of tackling this problem.

The subject of bullock cart was then taken up. *Mr. Jenkins* described the three types of cart wheels mentioned in Messrs. Patel's and Paranjpe's note (Appendix VII, G.) and said that an attempt was being made in Bombay to utilise the ball-bearing fittings on to the ordinary country bullock cart. The results of experiments conducted so far showed that the ball-bearing country wheels were quite successful for draught purposes on all hard roads and these wheels will permit to increase the load by thirty to forty per cent on all kinds of roads without increasing the draught over the country cart wheels. The carts fitted with ball-bearings have been found more useful than the country carts and less costly than rubber tyred carts. He advocated the future development of the bullock cart on the lines adopted in Bombay

Mr. Sayer remarked that he could not accept the tests which had been made as evidence of the value of the new invention He noticed that all the trials had been made on hard and medium hard surface He personally did not know how farm carts were used on Bombay farms whether they go on the cultivated land and how they were loaded up. Let them try and realise that if a cart with the artillery type of wheel goes on to soft or wet surface, it at once begins to show a great increase in resistance, increasing as the wetness or softness increases This is not the case with the Dunlop wheel. He agreed with Mr. Jenkins that it was most important to reduce the cost and this was a point they had continuously before them.

Mr. Charley said that the note contained a number of loose statements and errors. Referring to the list of disadvantages which had been levelled against the rubber-tyred wheel at the beginning of the note (Appendix VII, G.), he challenged the

authors' statement and said that there were no real disadvantages apart perhaps from the high first cost. He contended that the authors had missed the point. The defects of the country cart wheel were not in the hub but in the tyre. They had gone to great pains to equip the hub with ball bearings, and had thereby effected a saving of 20 lb. in draught by reducing hub friction. Mr. Charley was inclined to think that the saving of 20 lb. was more than a true figure; however, he was prepared to let them have it. That was all they were going to get. The saving would not increase appreciably no matter with what loads they made their comparative tests, and it was, of course, not influenced at all by the kind of surface on which the draught tests were made. Hub friction had no connection whatever with track resistance. He then quoted results of draught tests he had made himself to show the advantages of the rubber-tyred wheels.

	Country cart. One ton gross. lb.	Rubber-tyred cart. One ton gross. lb.
Hard road	25	35
Good metalled road	35	40
Average metalled road	50	45
Gravel road	70	45
Hard earth road	85	45
Dry soft earth road	170	85
Loose sand	400	150
Ploughed field	420	190

With their extraordinary draught reducing propensities on the rougher and softer surfaces, to say nothing of their very much greater load carrying capacity and other advantages, they completely eclipsed the ball bearing country wheel with its small solitary advantage of a mere 20 lb. saving in draught. He admitted that the rubber-tyred cart pulled a few pounds heavier on very hard, smooth road, but the extent to which carts were used on such surfaces was negligible Besides, the few pounds heavier draught on such rare surfaces was negligible, and the rubber-tyred cart had so many other advantages He referred to the enormous saving to the roads.

In addition to their tests on the level, the authors had made tests on a gradient. There was no point in this, of course; it was just as senseless as testing the speed of an airoplane against a headwind of known velocity, and, unfortunately for

the authors, it had furnished a check on their figures. On the same gradient, under the same conditions of surface and loading, their figure for the saving in draught was considerably different in proportion from the saving measured on the level, which showed that one or other of the figures was wrong. And the authors' estimate of the life of the rubber tyres and the cost of maintenance of the rubber-tyred cart was completely in error. It was a bad guess.

Mr. Charley did not like the idea of ball bearings for the hub, and the practice of setting the bearings directly into the recesses in the wooden hub could not, for a moment, be accepted. If they must fit frictionless bearings to their country wheel, they should be tapered roller bearings which are capable of adjustment, properly set in a metal housing, and properly fitted on an accurately turned axle. The Dunlop wheel gave all this in addition to its wonderful rubber tyre. He contended that the authors were misdirecting their efforts and wasting their time. For road and farm transport, the rubber-tyred cart wheel had overwhelming advantages It was well established in other countries and had come to stay in India.

In regard to ploughs, he said, there was a tendency to regard the modern, mouldboard plough as a panacea for all ills, which it certainly was not It could only play a part with other implements as a means to an end and not as an end in itself. He said that Messrs. Allan and Johnston had written a lot on the subject of inversion *versus* non-inversion ploughing, but nowhere in their test reports could he see any mention as to the degree of inversion which had been effected He had so often seen small, mouldboard ploughs giving no more inversion than country ploughs, particularly when they were being worked on their points, or with their mouldboards stuck full of soil as they so often were It was no use talking about inversion and estimating the effect of it if there had been no inversion or very little inversion. In future tests, this factor should be closely observed and taken into account. Everyone thought of the mouldboard plough merely in terms of inversion. An equally, if not more, important function of the mouldboard, was to pulverise. It was probably true to say that most of the types of mouldboards produced were primarily pulverising mouldboards. Mr. Charley thought that much of the advantage which had been attributed to inversion, in the tests referred to by Messrs. Allan and Johnston, might be due to better tilth due to better pulverising. He would

like to see much more talk and attention devoted to tilth and not so much to inversion. Although it might not be possible to make out a strong case, at all times, for the mouldboard plough, on the grounds of inversion, he considered it the best primary tool in the preparation of tilth, and thought it would not be displaced.

Dr Burns said tbat Mr. Roberts had suggested the following resolution:

"The Board recommends that all provinces and states

(a) collect a museum of indigenous implements in use,

(b) prepare and publish a description with photographs of all indigenous implements as well as improved types in use in their territory."

Mr. Jenkins seconded the resolution which was unanimously passed.

Mr. Jenkins said that they had tried rubber tyres on Government farm in Sind but without success.

Dr. Burns said that the question of rubber tyres must be further examined with more experimentation to see how far they were going to be suitable for village conditions The subject of implements had shown very clearly how very much the implement study was tied up with other things particularly with soil science, the question of tilth, for example, was one which could be pursued a lot further particularly in relation to the question of inversion and pulverising effect, particularly the effect of newly designed rotary implements which broke up soils into something like the pulverised state in one operation. He was sorry that the discussion had to terminate. Dr. Burns requested members concerned to go through the minutes very carefully and make the record of this debate as complete and scientific as possible.

Subject V.—"A Review of the work done on water requirements of crops and an appreciation of the present position with suggestions for the future."

Dr. Rege, in introducing the subject, explained various important points in his note (Appendix VIII, A.) and said—

"I have attempted to take a concise review of the work on the water-requirement of agricultural crops so far done in India and I do not propose to repeat it again. This review is

keeping sealed pots in line with the crop in open field would be more reliable than conducting the experiment in the pot culture shed. It has been, however, recently shown by Wordsworth in his experiments with sugarcane that plants absorb water through the leaves and carry it to the soil. This method of exposure of the leaves to the rain and dew is thus likely to vitiate the experiment even though the pots may be thoroughly sealed to prevent direct absorption by the soil. Further the thermal soil fluctuations in the pots have been found to be of higher magnitude than in the field. The influence of soil temperatures on water consumption has received scanty attention so far; but some precise study of potometer experiments by Vasque have shown that within the limits of 10° to 15°C., water absorption rapidly increases under the influence of a higher temperature.

Other important factors which determine the water requirement of crops are soil types, methods of irrigation, soil moisture, methods of cultivation and the proximity of the subsoil water-table and in all these it would be seen, the pot culture method differs in some respects or other from the field conditions. According to the modern genetic method of soil classification, the profile characteristics are considered to give a true index of the soil type and in the pot culture method where the soil is to be dug out and packed, the characteristic features of the profile are completely disturbed even though great care may be taken to replace the soil in layers. The most obvious effect observed is on the root penetration specially in the heavier soil types as the black cotton soil of the Deccan Canal tract. It has been found, for instance, during our researches on sugarcane that while in the field the root system had been very poor with a depth of penetration of about 18", the same soil when transferred to the pots showed a very free development of roots throughout the 24" depth. It must be also remembered that these pot culture experiments are generally conducted with surface one to two feet of soil, while it has been the common experience that in certain soil groups the roots tap much deeper layers. In Sind, for instance, cotton roots were observed to reach a depth of 8', while in Bihar the sugarcane roots are found to penetrate up to 5' or 6'. According to Viemayer, the depth of the penetration of plant roots under natural conditions coupled with the knowledge of the moisture equivalent of the soil is an important feature for basing the irrigation practice and this has in fact revolutionised the irrigation system in California

irrigation, however, it can be divided into "effective" and "non-effective". "

The Chairman said that he would like to focus the attention of the Board to the discussion of the point as to how far during the last few years attempts have been made to get an exact idea of the water required in a particular place, for a particular crop and on what conditions If no such information was available what measures should be taken to get to that accuracy. The opinions of the visitors to the Board who were directly interested in the problem from the irrigation side would be welcome.

others is well known in this connection and need not be repeated. I want to point out, however, that this method cannot be taken as the be-all and end-all of the practical recommendations as regards the irrigational quantities under field conditions or in other words transplanting these results *in toto* to the field conditions may lead to failure. As an instance, I may say that while in Bengal, the total water-requirement of the rice has been shown to be under 30″ by the pot culture method, under field conditions, the amount of 40″ total depth is held to be the minimum necessity for the successful crop of rice. Similar has been the experience with sugarcane in the Deccan canal tract. There has also been a great deal of pot culture experimentation and we shall have now to turn our attention to the field aspect of the problem.

It is no doubt a very complicated affair to measure the transpiration of a plant in its natural habitat with a normally developed root system spreading unhindered in the soil. The field investigation is not also so amenable to accuracy as is possible under pot culture experimentation. It is however considered that a very reliable data could be obtained in case certain conditions are satisfied. One obvious cause of inaccuracy is the loss by seepage through the irrigational channels. It has been in fact estimated that the loss due both to evaporation and percolation, comes to such a large figure as about forty-five per cent. from the head of the canal, while even in water courses about twenty-two per cent. of the water delivered is lost in this way. In recent experiments, this loss is eliminated by delivery of the water through cement channels as in Sind or through underground hume pipes as at Padegaon. The plot size is another important consideration, which would depend upon the lie of the land. The plot size for the dry farming in the ratio of 1 : 10 would be impracticable from the standpoint of uniform distribution of irrigation. At Padegaon we have found the plot size 32′ × 54·5′ in the ratio of about 1 : 1·5 to be quite suitable where the gradient is above 1 in 500. Further the field investigation should have to be necessarily a comparative one with three to four different deltas. For this purpose it would be necessary to have some preliminary knowledge of the moisture equivalent of the soil and root penetration. In order to get a critical result one or two treatments below what is considered to be the optimum and some above will have to be introduced. Another cause of inaccuracy is the rainfall which is an uncontrollable factor. From the standpoint of

irrigation, however, it can be divided into "effective" and "non-effective". "

The Chairman said that he would like to focus the attention of the Board to the discussion of the point as to how far during the last few years attempts have been made to get an exact idea of the water required in a particular place, for a particular crop and on what conditions. If no such information was available what measures should be taken to get to that accuracy. The opinions of the visitors to the Board who were directly interested in the problem from the irrigation side would be welcome.

Dr. Puri said that in all the work of water-requirement, a very important factor had been overlooked, *i e*, the amount of water lost by seepage in the soil. He did not mean seepage through irrigation channels. This loss of water depended on the frequency and intensity of irrigation and type of soil irrigated. Anything from forty to seventy per cent. of the water is lost and it was for this reason that the work done in pot cultures where this loss was eliminated was usually one hundred per cent. off the mark. In many cases the water-requirements, as determined by pot culture, was only half of what was found in the field. It was important that this factor should be taken into consideration in all future studies of water-requirement Very little water came from the water-table for the use of plants if the water-table was deeper than 5′ to 6′ because the capillary pull did not extend very high. But some water was lost or was evaporated not by the capillary movement but by the film movement. This water was therefore important not because it added to the water required by the plant, but in actually reducing the loss of water that was put on the soil for the use of the plant. Another factor which should be taken into consideration was the depth of the water-table not because it supplied water but because it reduced the losses that were likely to take place in the water put on the soil.

The *Chairman* (Dr. W Burns) said that he had recently had occasion to be present at discussions of the Research Officers of the Irrigation Department and those of the Board of Irrigation itself. They had prepared a questionnaire on conditions pre-disposing to harmful saturation which might ultimately result in waterlogging to which answers had been given by great many people. He asked Messrs. Richardson, Bedford and Bigsby to give their ideas as to how the irrigation Department as a whole tackled this question looking at the matter from the agricultural point of view.

Mr. Bigsby said that from the irrigation point of view the most important thing was for the Agricultural Department to realise in dry provinces that water was limited and therefore research should be directed from irrigation point of view to obtaining the best dividend from the cusec of water rather than from the acre of land. No research had been done in that line and there the Irrigation Department to some extent came in conflict with the Agricultural Department. Particular attention should be paid to this question. He would also stress the importance, in view of the subject of tube-wells, of finding the water-requirements at various stages of the crop. These would vary very considerably with the climate. In the Northern Punjab the limiting factor as regards *rabi* was the water available at sowing period. Very little was known of water-requirements in the intermediate and at maturing periods. It was extremely important from the point of view of tube-wells to know whether the cultivator could economise water during the intermediate stages after the sowing was finished.

Mr. Bedford said that there were some points in connection with the economical use of water that might be overlooked. When the Punjab started a new canal system large areas of land were reserved and given out to ordinary zamindars. The majority of these knew well irrigation intimately. Before they were given canal lands they used well water economically. The reasons why they used canal water apparently uneconomically appeared to be that on the wells there are generally a large number of human beings on a small area of land and a very small quantity of water. They had to spread that water with the greatest economy and they had free home labour which could be utilised. He thought it was fallacious to attempt to draw any conclusions, from a study of the water used from open wells assuming a cash value for the labour which was put into the work. The labour was free and when a man was given larger areas of land and a bigger supply of water but had not the labour the result was that he had to use more water. The amount of water which a cultivator would use was purely an economic problem. Where he used more canal water it was because it paid the cultivator to do so. In the *Nili Bar* tract large areas were given out for temporary cultivation to big zamindars and also to small cultivators, the unit for the small man being a rectangle or two. The big man who had land of 1,000 to 2,000 acres on temporary cultivation used appreciably more water per unit than the small cultivator.

The reason was clear, the big man with a large block of land wants a big profit with the smallest expenditure and to do that he uses large quantities of water and small quantities of labour on a concentrated area of crop. The same thing is seen if we compare the water-requirement of older canals with the newer ones. The amount of water required to mature a crop was smaller on older canals. The holdings are smaller on the older canals and the number of human beings depending are larger. Here again the conditions were becoming similar to wells, small holdings and a large amount of free labour. During the maturing of the kharif crop and the sowing of the rabi there was always water shortage and the variation in the amount of Kharif and Rabi crops sown was purely economic. If the price of foodstuffs rose, the area irrigated went up because it paid the cultivator to spread his water over a bigger area. The cultivator knew that the outturn which he would get per acre would be reduced but the price having gone up it paid him to get a smaller surplus per acre because the price of that surplus was higher. When the price of the outturn dropped he used more water on a smaller area because the increase in water increased his output and he required a bigger surplus because the price of that surplus was less He was inclined to think, broadly speaking, that it was fallacious to try to get something for nothing in the use of water. If water was reduced, generally speaking outturn would be reduced.

Mr. Richardson said that a great deal of work had been done in fundamental research but not much had been done to guide the engineer in applying that research in his dealing with the cultivator. He suggested more co-operation between Irrigation and Agricultural Officers for the practical solution of any problem dealing with the application of water to the fields.

Mr. Mehta (Land Reclamation Officer, Punjab) said that in dealing with the subject of the water requirements of crops the main thing to consider was the soil The water requirements of crops were different with different types of soil.

In the canal irrigated tracts of the Punjab water is distributed under a "Wari" system, *i.e.*, the zemindar gets his turn for water after a certain number of days Out of this turn it is impossible for him to get water. In finding out the water requirements of crops, therefore, this limitation has to be taken into consideration.

The introduction of the "Khal Kiari System" brings about an appreciable saving in the amount of water required to mature crops.

In the Punjab colonies it has been found that the water of the water-table is capable of being lifted to a height which is characteristic of the soil itself. When the water-table rises to within this height from the natural surface the water required to mature crops is much less than when the water-table is very deep. At the same time the salts have a tendency to move towards the surface which, if cultivation is neglected, results in the soil becoming 'Thur' (Kalar). The future of Punjab agriculture can therefore be visualised in terms of high water-table and presence of salts in the soil. He suggested the designing of a new system of agriculture to suit these conditions. This would be a combined system of irrigation and drainage and crops that would be most suitable to grow with the water supply available.

Experiments carried out in waterlogged areas showed that if the water-table was kept in motion by digging drains it was possible to grow normal crops of sugarcane without the help of irrigation.

He was surprised to hear from Mr. Rege that sugarcane required as much as 95" of irrigation in addition to a rainfall of approximately 18".

Dr Rege explained that the total quantity of 95 inches included the rainfall of 17 to 18 inches.

Rao Bahadur Viswanath said that the question could be considered from two points of view, *i.e.*, (1) Duty of water and (2) water-requirements of crops. The attention of the departments of agriculture has mostly been turned towards duty but in course of these investigations several difficulties arose which required a good deal of fundamental knowledge for guidance. In the Godavari Delta the duty of water decreased with the acreage of land under irrigation, but no information was available to show which was more profitable whether more frequent irrigation with smaller quantity or very large quantity with less number of irrigations. This would probably vary with the nature of the soil. If the soils were highly saline or alkaline growing particularly a cereal crop it would be necessary to dodge that irrigation as it were not to allow the salts to go down to the roots and injure the crop. But when the salts had unfortunately gone down on account of the rainfall or ex-

cessive irrigation it was to be adjusted by way of smaller irrigation to supply moisture to the surface roots. Again there was no information available on the minimum concentration of water necessary in a given soil for the optimum development of plant growth. Dr. Leather's experiments about 25 years ago, had shown that in a loamy soil the minimum concentration of ten per cent. moisture was enough to bring the crop to proper development and maturity whereas on the other hand in a stiff black soil twenty-five to thirty per cent. of moisture was required to produce anything but a meagre growth. It seemed to him that even within twenty-five years past between Dr. Leather and the other workers from the scientific point of view they had not gone a stage further in elucidating some of those fundamental problems. The first problem to which he drew attention was to know whether the movement of water through the soil per unit of time was governed by the concentration, the physical properties of water and the temperature conditions obtaining, and whether it was possible, to devise a method by which these could be accurately ascertained for any given soil. It would then be possible to find out the capacity of the soil to deliver water. Reference had been made to pot culture experiments and finding of a transpiration ratio. He said that it was not at all safe to attach any importance whatsoever to the figures that had been obtained by pot culture experiments for the purpose of determining water requirements of a particular crop Here again Dr Leather had definitely shown in his work that the mass of the soil had a considerable influence on the transpiration ratio The smaller the loss, the greater the ratio For instance, if two sizes of pots were used, the smaller sized pot would give a higher ratio than the bigger sized pot He said that in fixing the water requirements of crops, pot culture work was not at all a safe method At the same time, he did not wish to condemn the pot culture method because in the first instance as the plant-breeder went on producing new varieties of crops, it would be necessary in the first instance to have a rough and ready method by which it could be known comparatively, what were the water requirements of these new productions. This could probably be done under controlled conditions in pot culture experiments with a view to eliminating those that appeared to be requiring large quantities of water In regard to capillarity, it used to be thought that capillary movement of water took place in the soil through even greater depths. This view was held thirty years ago. Dr. Leather was again the first to

point out that this view was not valid and subsequent workers particularly Dr. Keen in Rothamsted in 1919 and other workers in America and elsewhere had shown that capillary movement of water for purposes of feeding the crop took place only through a range of very limited depth. That view had now been accepted. On this basis several experiments in which soil moisture and plant nutrition were concerned were explained but there was again one difficulty which from his experience had come prominently to notice. If after heavy rainfall a period of drought occurred the next rainfall even though it was much below the normal pulled up the crop and brought it on to maturity It was not known whether in period of drought moisture movement from lower layers was not big enough to support the crop-growth when smaller quantities of rainfall occurred in the next year. This point required to be looked into.

Mr. Jenkins said that his experience related to irrigated agriculture, very largely in Sind. Referring to the matter raised by Mr. Richardson, he said that it was of primary importance that there should be the closest co-operation between Irrigation and the Agricultural Officers in the study of practical methods of application of irrigation. As an instance of the advantage of this co-operation, he referred first to canal closures. In Sind it was found that a closure proposed to take place sometime about March would adversely affect either the American cotton or the wheat growers. The Agricultural Department's contribution towards the solution of this problem was the introduction of an early maturing variety of wheat and the early sowing of wheat by the preservation of soil moisture by mechanical methods to enable wheat to be sown in October, so that a March closure did not affect the crop.

Again there was the question of frost. One remedy or palliative against frost-attack was the application of light irrigations to the fields when frost damage was apprehended. The Irrigation department could assist a great deal in this direction by allowing water at the proper time which would at least reduce the extent of frost-damage considerably. Another illustration of the advantage of such co-operation was seen in the Karachi district where it was found that the rice crop was now suffering considerabl [illegible] lack of water. This was said to be due to the off-ta[illegible] The Agricultural Department, in [illegible]ulty, introduced a variety of rice wh[illegible]

shorter period and which could be grown on the reduced water supply, which was available after the Barrage commenced. In such ways one could illustrate very satisfactorily the absolute inter-dependence of the Irrigation and Agricultural Departments. In Sind, they were dealing with cultivators who were used to inundation conditions Since perennial irrigation had been introduced, there was a very great tendency to utilise much more water than was really necessary Warnings has been issued that this would result in lower cutturn of crops and permanent damage to the soil. They were also concentrating their attention in getting the most cultivation out of a cusec of water and not out of an acre of land. He drew attention to the necessity of any future work on water requirements of crops being done in the closest contact with actual field conditions.

He said that he had seen with admiration the work of Dr. MacKenzie Taylor on hydrodynamics and technical engineering matters and the extent to which they had affected actual irrigation practice. He thought that that type of research must essentially be carried out by engineers and that the fullest facilities should be given to agricultural officers to enable them to understand them fully. On the other side was the question of irrigation research connected with purely agricultural subjects such as mentioned by Dr. Rege Such work should be done by agricultural officers with a definite practical knowledge of irriganion, who should be chosen not entirely on the basis of their scientific ability in the laboratory but with reference to their practical experience in the field as well if the results of such irrigation research were in future to be brought into closer contact with practical problems of irrigation farming. In order to emphasise his point, he moved the following resolution :—

"The Board desires to draw attention to the necessity for increased scientific research on the relations between soils, water and growing crops and on allied problems connected with irrigated agriculture in India. It emphasises the importance of such investigations being conducted by officers of the Agricultural Departments, with practical experience of crop production under irrigated conditions, and recommends that this policy be followed if and when a Central Irrigation Institute, as recommended by Sir John Russell, is established."

Mr. Roberts, in seconding the resolution, endorsed very heartily the opinion expressed by Mr. Richardson and supplemented by Mr. Jenkins, that for real progress, the very closest co-operation between agricultural workers and irrigation officers was essential. The practical proof of this necessity was to be seen in the fact that three Chief Engineers of the Punjab in spite of their heavy engagements had been regularly attending the meetings of this Board. He drew attention to the point that was emphasised by Mr. Bigsby and touched on by Mr. Jenkins that we should aim at studying the problem, as far as the canal water was concerned from the point of view of getting the greatest use of the cusec, *i.e.*, spreading a cusec of water on the largest possible area. He drew attention to one aspect of that question which might be misleading. Here in the Punjab they had their area divided into squares of twenty-five acres. Each square was supposed to get the same amount of water. Now a poor soil may yield one hundred maunds of wheat in the *rabi* season, whereas with the same amount of water good land may yield 200 maunds while paying the same irrigation duty. He therefore emphasised that efforts should be concentrated on getting the best possible results in yield *per cusec*. It was not really a question of the area on which to spread the water as much as the amount of the produce that could be got per cusec.

Rao Sahib Thadani fully endorsed the resolution and said that in Sind they were doing their best to utilise one cusec of water on as much an area as possible and were carrying on propaganda amongst cultivators to divide their land into suitable plots and make the best use of water supplied.

Mr. Richards said that their department felt that they should definitely get down to the question of the practical distribution of water to the best advantage so as to make the available supply beneficial to a larger number of people rather than to get a maximum amount of advantage to a small number. They were not in a position to be able to say in respect of any tract as to what was the most profitable distribution and would not be able to do so from any experiments conducted on the Government farms.—They found from the investigations carried out particularly on sugarcane and rice that they got very different results from areas which were not very wide apart. They had therefore quite a lot of work which would have to be done practically in the field and for this it would be essential, if they were ever to get at a solution of these

problems, that the field staff of the two departments work together, observe together, record together and the results of their observations be kept in view over a long period of years and correlated He hoped that as a result of this in the end they should be able to extend the actual area which could be irrigated in any average year with present available water supplies very considerably to the benefit of everybody. Further he said that it was not a matter which could be done in one year or even five years but a real solid beginning should be made immediately with both the research and field staff in order to achieve the desired object

Dr. Crowther described his experiences in Egypt and the Sudan regarding water requirements and the *sizes* of plots. He said that he had no idea what was the water requirement in inches for crops in Egypt and the Sudan and suggested that pot cultures could be of little help in deciding water requirements of field crops where leaching and surface evaporation were important. The size of plot for irrigation of cotton in Egypt was usually about 100 sq. yards, for wheat it was half that for cotton and for maize half that for wheat, maize being exceedingly sensitive to waterlogging. The more permeable the soil the smaller must be the units for irrigation as the risk of waterlogging increases

Dr. Burns said that the discussion had been extremely useful and while it had not gone deeply into technical details it had certainly been extraordinarily useful as it had dealt so effectively with principles He was certain that it would result in very much closer co-operation between the Irrigation and the Agricultural Departments in the work that they were going to do in the future. It was extremely interesting and he was sure gratifying to the Irrigation authorities to notice how largely the idea of making a cusec of water go as far as possible had been dominating the work of the Agricultural Departments particularly in Sind

He then put the *resolution* to vote which was *carried unanimously*.

Subject VI.—A Review of work done on crop protection—an appreciation of the present position, with suggestions for the future ·

(a) With reference to protection from wild animals.

Mr. Jenkins, in introducing the subject, said that it was not a new one to the Board of Agriculture as it was discussed

in considerable detail both in 1925 and in 1929. However, i the Bombay Province the wild pig still continued to caus much damage to the crops and he doubted if the estimate damage of Rs. seventy lakhs to the cultivator by the ravage of this destructive animal had been greatly reduced. This problem had been discussed at the Bombay Provincial Boarc of Agriculture in 1921. As a result, a committee wa appointed to consider methods of checking the damage. Th main recommendations of this Committee were given in th note placed before the members of the Board These recommendations were considered by the Board of Agriculture in 1925. Since 1929, experience of gun clubs, especially in forest areas or in agricultural areas contiguous to the large forest tracts of the Southern Division of the Bombay Province had shown that this method of dealing with the pest held out more prospects of successful results at an economical cost than any other. The cost of a gun-club must vary according to its membership and the area it had to protect, but an average of Rs. 500 might be taken per year The wild pig was estimated to consume -/4/- worth of agricultural produce per day. In addition watching the crops by night had a deleterious effect on the cultivator in malarial districts In many parts of the Bombay Province the damage by pig had reached such an extent that it ruled out any possibility of growing leguminous crops after paddy It was obvious that such small expenditure on an insurance of this type was not an excessive premium to pay. He had visited several of these clubs and, apart from the records of pigs killed, it was notable that in many areas in which the gun-clubs were working, the cultivation of leguminous crops had again commenced. The rules for the organisation and working of gun-clubs in jungle tracts [Appendix A of his note (Appendix IX, A)] were worth consideration for adoption in other parts of India where this pest was a serious trouble to cultivation. He suggested that in areas where this trouble was reported to be serious the Forest and the Revenue Departments should be approached for the issue of licences for guns to *bona fide* cultivators on a much larger scale. The *Nilgai* was another animal which was causing considerable damage to cultivation in many parts of the Bombay Province. In spite of this, there was great reluctance on the part of the Revenue Department and Forest Department to increase such facilities to responsible cultivators to protect their crops. In the past the military had been used for destroying wild animals in certain areas. He suggested that such work could be incorporated in the annual training

of armed police but he had not yet consulted the Inspector-General of Police with regard to the feasibility of this suggestion.

Protection of crops by fencing was of limited application. Not only was the cost of fencing high, but it was difficult to ensure the co-operation of cultivators whose lands one wished to protect. Legislation had been enacted by which the co-operation of cultivators could be enforced, provided a certain number agreed to co-operate in a scheme of this sort. But until the cost of fencing was cheapened, this form of protection could not be successful except in limited areas where very valuable irrigated crops were grown

At a previous meeting of the Board, the appointment of a special officer to study the life-history of wild animals with a view to devising more effective control measures was recommended. This should be given effect to as soon as possible. As an alternative, he would suggest that a circular might be sent round to the Forest Department that Forest Officers touring through jungles might make observations with regard to the habits of wild animals destructive to crops which could be collected and considered with a view to undertaking more effective measures for their destruction.

Finally, he suggested experiments in the trapping of wild pigs and *nilgais* on the lines suggested in his note with modifications suitable to local conditions. He added that such work would well repay its cost and would be a useful check on the extension of damage done.

Jackals were injurious raiders of sugarcane crop and could be dealt with by poison baits under careful supervision. Poison baits had proved effective in many parts of the Bombay Presidency.

A few small areas were damaged by elephants. These should be left to be dealt with by professional *shikaris*

Rats and crabs also damaged largely rice crops The Department had devised methods for dealing with rats by fumigation of their burrows with hydro-cyanic gas and similar measures, but they did not seem to have caught on. Government had sanctioned rewards for the destruction of rats. The question demanded serious consideration He did not think much had been done on the lines suggested by the previous Boards. Apart from the development of gun-clubs in the Bombay Presidency he did not know of any other steps which

had been taken with any degree of effectiveness towards checking the damage to crops by wild animals.

Mr. Allan said that *nilgai* was the chief cause of damage in Baroda. The position was that the Baroda people chased *nilgai* to the Bombay Presidency and the Bombay Presidency people chased them back to the Baroda territory. In Baroda people treated *nilgai* as something related to the cow. It was impossible to kill *nilgai* by gun-clubs. Although ryots desired that *nilgai* should be destroyed, yet any offer suggested to them by which *nilgai* could be destroyed seemed contrary to their religious ideas. He suggested, that the Police might be used for the destruction of *nilgai*.

Dr. Burns cited an effective shoot of *nilgai* in the Nadiad district where the damage had been so bad that the cultivators made no objection to the killing of the *nilgai*.

Mr. Wynne Sayer said that starting of gun-clubs as advocated by Mr. Jenkins did not appeal to him an effective remedy. Even if the villagers killed pigs at the rate of one pig per man per year it was doubtful if they could finish all the animals. Fencing was not economic and he did not see any possibility of fencing all the lands adjoining the forests.

Khan Bahadur Fateh-ud-Din said that the *Nilgai* and the monkeys were a serious trouble in the Punjab, but the difficulty in combating with them was that they were considered sacred by the Hindus. Rats were another serious trouble in the Punjab and did considerable damage They had conducted some campaigns on very extensive scale in some cases covering an area of about 1,500 acres at a time, but it was found that it was not quite effective and cheap The peasant was not prepared to spend nor the Government. He suggested that in places where such trouble was serious a special tax should be levied on those people to arrange such compaigns.

Mr. Fotedar (Kashmir) said that rats were their serious trouble in the saffron fields in Kashmir. They had tried several methods for their control such as calcium cyanide, sulphur and poisonous baits, and drenching live holes with water, but the cultivator did not like their methods. They only used their old method, *viz.*, of putting some dry cowdung in an earthen vessel with a hole on one side and setting fire to it. They blew with their mouth and sometimes with bellows into the holes and by this method they were able to make one rat come out in fifteen minutes by the smoke. For this operation they spent the major portion of their day during the season and thus saved their costly crop of saffron.

Sardar Harchand Singh (Patiala) said that they in Patiala had devised a very simple apparatus costing about one rupee, for exterminating rats. This was found to be very useful and had been favourably commended by the Board of Agriculture in 1929 at Pusa. This was on exhibition in the Lahore Exhibition. In regard to jackals they had got a variety of thick chewing canes in the Patiala State which was the favourite of jackals. They had devised a simple method of protection by wrapping the leaves of plants around them which they recommended to the cultivators costing about Rs. 5 per acre.

Dr. Burns differed from the view-point of Mr. W. Sayer that the control measures for wild pigs could not be made effective. The local effect of a gun-club was immense. He strongly suggested organisation of gun-clubs which could be run at a very cheap cost, *e.g.*, only by the supply of cartridges and guns. In this the co-operation both of forest and the police officials was essential in order to be sure that they were prepared to bless these licenses and also for shooting in reserved jungles at certain times. The co-operation of sportsmen in the neighbourhood should also be enlisted. He could say from experience that the effect of gun-clubs in the neighbourhood of Poona was marked. As far as the Bombay Presidency was concerned, the gun-clubs were successful. There was enough local enthusiasm and all that was wanted was organisation and control from above. Dealing with the control of other pests such as rats, etc., it was a matter of local arrangements depending on their severity.

Subject VI.—A Review of work done on crop protection—an appreciation of the present position, with suggestions for the future.

(b) With reference to protection from insects.

Dr. H. S. Pruthi in introducing his paper on plant protection from insect pests said as follows:—

"When I drew up my note (Appendix IX, C) on the subject of protection of crops against insect pests, I was under the impression that the whole of one after-noon would be devoted to the discussion of this important subject, and therefore attempted to review our knowledge of all the important pests individually. Now that not even one hour falls to the share of this subject, I cannot deal with various pests individually. Therefore, I will only briefly describe the general principles of insect control and indicate to what extent these principles are being applied in India.

Amount of damage.—Insects do considerable damage to crops, stored grains and other plant products. The actual amount of loss caused by insect pests has been worked out in several cases. About two years ago, when the Imperial Agricultural Research Institute was still at Pusa, we carried out a study to assess the damage done by borers to sugarcane. Data was collected and analysed statistically. It was noticed that the canes infested by the borers (8-10 per cent.) weighed about five per cent. less than the healthy canes and moreover their sucrose content was lower by about three per cent. (13·07 against 16·2) and their purity was also about four or five per cent. less than that of the healthy canes. Richards working at Muzaffarnagar reports that the top-borer of sugarcane with an average infestation of about twenty-five per cent. in a standard variety like Co. 312 suffers a loss of 123 maunds per acre. Haldane has recently estimated the loss caused by cane borers. He examined and analysed canes received by ten factories in the United Provinces and Bihar and found that the infested (17-57 per cent.) canes weighed about four per cent. less and yielded one per cent. less sugar than the healthy ones He estimated the cash value of this loss at Rs. 17,50,000 in one season.

Deshpande working on cotton bollworms in the Bombay Presidency reported that the crops protected against the infestation yielded fifteen, fifty-four and eighty per cent. more *Kapas* in three years respectively. The estimated yield of cotton in 1933-34 (Statistical Abstracts) was 64,92,000 bales. Taking even the lowest estimate of fifteen per cent. reported by Deshpande to represent the average loss, the total amount of cotton destroyed by bollworms works out to be 9½ lacs of bales per annum. In view of the figures now quoted, if we now consider that on an average about ten per cent. of crop-yields are destroyed by insects, I think we will not be exaggerating the estimates. If this estimate of damage is accepted and the cash value of Indian crops is about 1,000 crores of rupees as stated by Dr. Wright in his report, the total loss caused by insects to Indian agriculture works out at Rs. 100 crores per annum. This estimate sounds too big to be believed but as I have explained is based on published figures.

The most important object of agricultural research is to increase the yield of crops. But it appears that in India adequate measures are not being taken to conserve the yield against the ravages of insects for about half of the Provinces and eighty per cent. of States have not yet got entomologists or mycologists.

To try to produce more and at the same time not preserve what one has already got is obviously not sound economics.

The various methods used for controlling insect pests can be grouped into five or six categories, namely,—

1. Preventing foreign pests from entering the country.
2 Use of resistant varieties.
3. Increasing the resistance of plants by artificial means —such as manuring, etc.
4. Modifications in cultural practices—such as early or late sowing and harvesting to dodge the pests and growing early and late maturing varieties
5 Biological methods of controlling insect pests.
6. Directly killing the pests with insecticides and fumigants or by physical and mechanical means. such as bagging, trapping hand-picking, etc.

I.—*Preventing foreign pests from entering the country.*

The saying "prevention is better thnn cure" is very true in the case of insect pests.

It is common experience that pests often do more harm in a new country into which they enter than in that from which they have come. With quick means of transport it is very difficult to prevent foreign pests from entering a new country. It need hardly be pointed out that it is far more economical to keep out foreign pests if it is possible or deal with them soon after their entry than to wait till they have spread into the country.

An instance of a bad pest which has come into India during the last twenty-five years is the San Jose Scale. The amount of damage this pest is doing in North India is well known. It is seriously suspected that it came into this country from Afghanistan. Under the Insect Pests Act of 1914 we have powers to disinfect all plant material when it is imported into India by sea, but at present we have no powers to regulate the imports entering this country by land routes. The motor traffic has increased the danger of importing foreign pests by land. In old days, especially across the frontiers of India, the journeys used to take very long and many pests died out *en route.* Another foreign pest which is rapidly becoming prominent is the *Wooly Aphis* or the American Blight. It is already serious in the United Provinces Punjab and Kashmir.

There is another notorious foreign pest which attracted our attention only a few years ago. A member of my staff, while touring in Baluchistan in 1933-34, observed that apples in several gardens in that Province were being damaged by a pest similar to Codling Moth. The specimen were carefully examined at Pusa and were found to be those of the real Codling Moth. The attention of the Imperial Council of Agricultural Research was drawn to these facts. The Council gave me the assistance of a small staff to survey all the fruit-growing tracts of Baluchistan with a view to ascertaining the exact distribution and status of this pest. The survey has been recently completed and I am in a position to state that the pest is already fully established in certain parts of Baluchistan where more than seventy per cent of the fruit gets destroyed by this pest. I will ask your permission to describe some features of the biology of this pest as the account will clearly indicate the weak points in our defensive measures against the entry of foreign pests into India ".

Dr. Pruthi described the life-history and method of damage of Codling Moth, which he illustrated with a plate in colour. He continued as follows :—

"You will be concerned to know that the Pest is also present in the North-West Frontier Province.".

The habits of the pest are such that it can spread from one part to another chiefly through the infested fruit. Suspecting that Codling Moth probably entered and is entering India from Afghanistan, I had some baskets of fruit coming from Kandahar, purchased and examined at Chaman by my staff. Several apples in the baskets showed Codling Moth damage.

The account of Codling Moth clearly shows that we must strengthen our defence against the entry of foreign pests into India in two ways—(a) The possibility of taking quarantine measures at the land frontiers, as is being done at sea ports, should be seriously considered.—(b) You are all aware that at present fruit and vegetables are exempt from the operation of the Pest Act. As there are several other pests, *e.g.*, fruit flies, scale insects, phytophagous chalcids which can spread while carried inside or on the surface of the fruit and vegetables, we should consider the question of at least demanding certificate of health from the exporters in the foreign countries, as is being done in the cases of other plant material. Since 1914 when the Pest Act was premulgated and fruits and vegetables were exempted from its operation, conditions of

transport have undergone considerable changes. At that time transport was very slow and most of the cargo ships had no refrigeration equipment; therefore even if there were some insects on fruit, etc., at the beginning of the journey they in most cases completed their development and left the fruit *en route*.

In this connection you will be interested to know that almost all the important countries of the world have restrictions against the promiscuous import of fruits and vegetables.

Before describing the various methods of controlling pests which already exist in the country, I want to emphasise the importance of a close study of the pest in all stages of its development in order to decide as to which method should be attempted in the particular case. This preliminary study of the identity and biology of the pest is of the utmost importance, for it is this study which reveals vulnerable points in the life of the pest at which it can be attacked with advantage. I have thought it desirable to emphasise this point as Sir John Russell's Report is liable to convey the impression to non-entomological workers that the study of life-histories of pests is not of much importance. Owing to the efforts of the Entomological Section at Pusa and in some of the Provinces, we at present possess such knowledge about most of the serious pests of our country. Of the important pests which still need even preliminary and fundamental work of this kind, white-ants come to one's mind first. The complete life-or seasonal history of not a single species of white-ants has yet been worked out in this country.

2. Use of Resistant Varieties

The fact that some varieties of crops are resistant to the insect attack has been established for some time. The use of a resistant variety possesses the obvious advantage that it dispenses with the need for other protective measures. Hence this method, if successful, is most economical.

A number of varieties have been studied from this view-point in several parts of India. The Uppam cotton in Madras and the Broach cotton in Burma have been reported to be resistant to the attack of Boll worms. *Desi* cottons are most resistant to Jassid attack than American varieties. The Coimbatore varieties 312 and 411 of sugarcane in the United Provinces, 299, 313, 331 at Pusa and CO 285 in the Punjab have been found to be more resistant to borer attack than others. CO 205 and 285 having narrow and hard leaves have been reported to be resistant to Pyrilla attack in the South-Eastern districts of the Punjab.

From the list of resistant varieties which I have just now given it will be noticed that the anti-insect resistance of the various varieties is not the same in all parts of the country. Every Province has to try and find out which varieties are more resistant than others in that area This is natural as the behaviour of various varieties including anti-insect resistance is very much dependent on local conditions.

In this connection I must point out that the so-called resistant varieties are only resistant when they are grown near other varieties which are more preferred by the pests. It is very likely that when the so-called resistant varieties are only available they might be attacked by pests as voraciously as the susceptible varieties are done at present. Thus the use of resistant varieties is not a permanent method of control. It affords a measure of protection for a short time only and therefore the selection of resistant varieties has to be continued always.

The real basis of work for the evolution of resistant varieties is the study of the factors which confer resistance. This work is of fundamental importance and has not received much attention in India The work on the Hession fly in the U. S. A. has shown that the attack on wheat varieties by this pest varied with the ash-content or the presence of silica. Resistance to Wooly Aphis has been associated with the presence of a hard tissue in the xylem vessels which prevents the penetration of the mouth parts of the aphid. In this way several other characters, *e.g.*, thick veins, hairs, etc., have been found to be responsible for confering resistance against various pests.

After determining the real cause of resistance the Entomologist has to seek the co-operation of the plant-breeder for evolving resistant varieties.

A question closely akin to the utilisation of resistant varieties is the increasing of plant resistance by artificial means, such as manurial and other treatments. The classic work of Andrews in Assam on the tea mosquito is well known. The resistance in tea bushes was induced by giving them potash manure. Work done at Rothamsted has shown that potash and phosphates induce resistance, whereas nitrogenous manures by causing more leafy and succulent growth makes the plant more attractive to insect pests."

Biological methods of controlling Insect pests.

In nature most insect pests have numerous enemies which include some other species of insects, bacteria, fungi, Protozoa, worms, fishes, and toads, birds and mammals. They are generally called parasites and predators. The utilisation of such enemies for controlling insect pests is known as the biological method of control. This method has a tremendous popular appeal, for if successful it is the ideal and permanent method of control. But unfortunately this method is not so simple as it sounds and it requires a great deal of labour, ingenuity, patience and expenditure to evolve a successful parasite.

The utilisation of parasites presents entirely different problems. depending upon whether one is dealing with parasites already occurring in the country or those imported from abroad. The two problems involve somewhat different principles. The use of indigenous parasites is comparatively simpler and I will give some examples of parasites which already exist in the country and which may be tried against some of our pests.

Pyrilla pest of sugarcane has two egg parasites in North *India, namely Tetrastichous pyrillae* and *Coencyrtous pyrillae*. Whereas the Pyrilla pest makes its appearance in the field in March or April the parasites are not evident before June. After this month there is steady increase in the number of parasites, till in November and December about eighty per cent. of the eggs of Pyrilla are parasatised in nature But unfortunately by this time the pest has already done good deal of damage, and therefore the parasites are not of much economic importance Evidently this account suggests that entomologists should endeavour to help the parasite in its propagation early in the season by breeding them under optimum conditions in the laboratory and liberating them in the field so that initial population of the parasite in the field is increased by artificial liberation

This method of artificial rearing and liberation of indigenous parasites has been utilised with successful results in other countries. In California several Aphid pests and mealy Bugs have been controlled by the local predators *Hippodamia convergen* and *Cruptolaemus montrouzei*. The predator *Encarsia flavoscutellus* is being tried in Java against the Wooly aphid of sugarcane with hopeful results.

under Indian conditions. People often apply doses prescribed for Europe or America. But as the toxicity and penetrative power of chemicals and gases depend on the prevailing temperature and humidity, the result is that sometimes we use too much chemicals entailing some unnecessary waste and sometimes too little with the consequence that the pest concerned is not killed. Thus the importance of a careful study of various insecticides and fumigants under Indian conditions can hardly be emphasised

Another line of work which is likely to make the use of insecticides profitable and popular in India is the preparation of insecticides from indigenous materials so that they may be available at cheap rates A beginning in this line has already been made at Bangalore and Dehra Dun where the insecticidal value of the common fish poison plants is being investigated. Examples of other materials from which insecticides can be prepared in India are tobacco, tars, crude oils, etc. India grows and exports tobacco in large quantities, but we are buying nicotine sulphate, a very commonly used insecticide which is made from tobacco products, at about Rs. 3-8-0 a lb.

Mr. Richards said that one matter which had not been touched upon and which he regarded as being of great importance in regard to quarantine was not only that of preventing insects coming into the country but of quarantining insects within the country. They had recently imported a most serious pest of fruit trees, in the Codling Moth, and unless very energetic steps were taken nothing was going to prevent the moth from spreading to every fruit-growing zone in India. It could only be prevented from spreading by ensuring that no infected material came out of the affected zones. They had at present no effective quarantine restrictions of any sort either by the Imperial or by the Local Government which could protect the unattacked areas from this very serious danger. Preventive steps should therefore be taken immediately.

He wished to describe three instances of the successful control of insects for the information of the botanical and agricultural members. Pyrilla lays its eggs almost invariably in the latter part of the season inside loose leaf-sheaths. It cannot get into the canes in which the leaf is tight and does not easily strip away. Such canes are very much less attacked by Pyrilla. That was a character which all officers who were dealing with the selection of sugarcanes could very readily

note and which was an inherent character and could be readily built up in new canes which were being bred.

Another instance was the work which had been done by Rai Bahadur R. L. Sethi and which had now developed to the stage of distribution of new varieties to the cultivators. It was the building up of a new strain of rice with a sheath-cover of the corn as protection against the rice insect—*Leptocorisa varicornis*—popularly known as *gundhi*.

The third was the prevention of coccids crawling up the mango trees by tying grease bands round the trunks.

Mr. Richards said that individual effort would be of little use. It was necessary to control pests like Pyrilla by means of an organised co-operative effort over a wide area and not to confine action to ameliorating the condition of a particular field. The same remarks applied in the case of borers A good deal of damage at Muzaffarnagar could have been prevented by the removal of fresh shoots, stubbles, first growth from ratoon cane and suckers from late seedling cane If that was done over a large area, a great deal of damage caused would have been prevented. In all such campaigns it was essential to educate the people who co-operated with the department and through them the cultivator and all other agencies who were interested in the welfare of the cultivator whether they be Irrigation Department, Revenue Department or honorary workers with the technique and the methods As a result of the work done on the Pink Bollworm in the United Provinces, a Pest Act was passed The Pink Boll worm in North India passed from one season to another in

Scale had been declared a pest. A considerable amount of annual spraying which during last year amounted to over five lakhs had been done with the help of the Government who supply free machinery and technical labour. He explained the restriction placed by this Act on imports, exports and quarantine of plants and suggested that similar Acts might be promulgated in other provinces and Indian States so that the whole problem could be solved in the right way.

The Chairman (Dr. W. Burns) pointed out that following up the spirit with which Sir Bryce Burt had conducted previous meetings, it would not be desirable to suggest administrative action. He understood the Government of India were already considering the question of inter-provincial traffic in plants. He did not think it necessary to go beyond purely technical matters in this meeting.

Rao Bahadur Viswanath said that the Imperial Entomologist would like to know the opinion of the Board about the exclusion of fruits and vegetables from the quarantine restrictions. Up to now fruits for consumption had no quarantine restrictions.

Khan Bahadur Fatehuddin said that Dr. Pruthi had just mentioned about the seriousness of San Jose Scale in the Punjab. A few years ago, this Scale was so bad that the fruit growers in Kulu and the Simla hills were thinking of cutting down their orchards, but now the pest was under control Spraying had proved effective. If there was no Act, some people would not do spraying.

Dr. Burns said that in a case of minorities like that, compulsion was necessary. *Mr. Fotedar* said that spraying was compulsory in Kashmir.

Mr. Richards said that the question of fruit quarantine was a thorny question which all Governments would avoid if they possibly could. So far quarantine had not been insisted upon by any Government. Where a particular pest was expected to be imported in a particular fruit or vegetable, as in the case of potatoes, the application of the Act was necessary. It would be a matter under the rules for deciding whether a particular place was to be allowed to be admitted or not. It would be impossible to place a general embargo on fruit.

The Chairman said that in any alteration of the Act, it should be possible to get powers to place an embargo on a particular fruit or vegetable from a particular place.

Rao Bahadur Viswanath said that fruits or vegetables they would be obviously be part of the quarantine regulations. Since fruits for consumption did come in, it would be governed by quarantine rules just as certificates were required in the case of potatoes.

Rai Sahib Thadani said that Sind was exporting apricots to Egypt and Egyptian authorities required certificate of immunity from diseases. If some such provision for an embargo could be made in the Act it would be helpful.

Dr. Burns said that administrative difficulties were enormous. If Liverpool could take up bananas, they would not like to be bothered with certificates. It was a thorny question. He enquired if Dr. Pruthi thought that there was any danger of the Codling Moth coming with fruits from Afghanistan and spreading in various parts of India.

Dr. Pruthi replied in the affirmative and said that Codling Moth has been studied only in Baluchistan. The next step was to study the potentialities of its development under different conditions. It is found in the North-West Frontier Province and the Kashmir, Kulu and the Kumaon hills could be easily attacked by this pest. For the rest of India nothing could be said till the pest had been studied.

Subject VI.—A Review of work done on crop protection—an appreciation of the present position, with suggestions for the future:

(c) With reference to protection from fungi.

Dr. Uppal, after a survey of the past history, of plant diseases and their control, dealt with the salient points in his note (Appendix IX, D) circulated to the Board He said fungus diseases could be divided into two main groups—those of aerial parts and root diseases. The first could he controlled by fungicides either in the form of spray or dust The other group which was caused by soil-borne fungi was very difficult to control The most common sprays were elementary sulphur. lime sulphur and copper sprays and he explained their relative merits. In Bombay they had found "Sulsol" a good spray. It could control not only ectoparasites hut also endophytic parasites. So far no proprietary compound of copper had come up to Boredeaux mixture Sulphur dust had proved successful in Bombay as a fungicide and insecticide especially in the case of mango mildew and hoppers. Powdery mildews of many other crops in Bombay were

similarly controlled. Mango hoppers could not be controlled by any very cheap method. Now they were employing sulphur dust. The cost of treatment by sulphur dust did not go beyond 0-15-0 per tree. The only possible method of controlling soil-borne diseases was by the development of resistant varieties. In Bombay work had been done on the development of a wilt-resistant variety of sann hemp which was a highly cross-fertilized crop. It was very difficult to multiply the seed of this crop. He had developed a technique by which seed could be multiplied. The method for the development of resistant varieties of crops had also been extensively developed as a result of their work on the production of wilt-resistant strains of cotton There had been much discussion as to whether what they were doing in Bombay was really worth while. This subject was discussed recently in a meeting of the Indian Central Cotton Committee where scientific workers in cotton were present and he had reported there this method of testing the resistance of varieties of cotton against wilt. Wilt in cotton was affected by two important factors. One was the degree of infestation of the soil by the pathogen and the other was the soil temperature. That meant that if a type of cotton which was susceptible was grown in a soil which was heavily contaminated and if it was subjected to adverse conditions of soil temperature, these plants showed temporary immunity resembling the inherited immunity of resistant plants at all temperatures. On the other hand, if susceptible types of cotton were grown in infected soil in a range of optimum temperature for the development of the fungus all plants wilted. This fact led them to develop the technique. It was sometimes argued that the field selection was just as good a method of selecting a strain and fixing it as pot culture. This viewpoint was based on a wrong assumption in the sense that the field selection could not give as accurate results. It was really the environment which was determining whether the disease would be caused in a particular strain when grown in a particular set of conditions. The relation of environment to the development of fusarium wilts in cotton and other crops is fundamental to the whole question of disease resistance since the term "Resistance" assumes different meanings when used with respect to a varying environment. It follows that field selected strains must vary in their wilt reaction according to seasonal conditions and the degree of infestation of soil by the pathogen. The method was not expensive or cumbersome. In the last season he tested during the course of two months, fifty thousand plants.

This was not possible under field conditions where it is difficult to control environmental conditions. The main object of the pot culture method then was to have strains which had higher level of safety than strains which could be selected under field conditions. If wilt in cotton was due to quantitative characters, as was recently stated then theoretically it might not be possible at all to get a strain which would be entirely immune under all conditions. Recently, however he got a strain in Kumpta cotton which did not wilt under any condition. It behaved exactly like the sunn hemp strain Similarly a highly resistant strain of pigeon pea had been produced although the highly wilt-resistant strain of pigeon pea developed under field conditions at Pusa suffered about 50 per cent., mortality from wilt when it was tested in wilt sick soil at Arhhavi Farm. It was well known that resistance in cotton or in other plants to Fusarium wilt diseases was inherited and that the genetic basis of this inheritance might differ in different plants At least two distinct types of inheritance have been recognised in this group of plant diseases. One was where the susceptible and resistant plant fell in two discontinuous classes and resistance might be due to a single immunity gene. This type of resistance could be readily fixed in a homozygous condition. In the other class it was not possible by repeated selection to fix the type and however, long this selection was continued, the ultimate plants showed a certain amount of susceptibility, but it was known especially in case of cabbage yellows that these two types of inheritance could exist in the same strain It was just likely that both the types of inheritance were also represented in cotton wilt as is the case in cabbage yellows

Antibiosis —Recent investigations had shown that there was potential promise for the future in the application of the principle of antibiosis under ordinary field conditions It was a common observation that some fungi growing in culture show antagonistic or antibiotic effect. This antagonistic action of fungi had a practical significance and it might ultimately be possible to devise a cropping scheme by which they could eliminate from the soils such a polyphagus fungus as *Sclerotium rolfsii*, which was common in all Indian soils and was difficult to eradicate.

Seed treatment was another method of control and the most important disease that could be controlled by this was smut disease. When the infection was carried on the seed, the latter is usually treated by a dust or liquid fungicide. In

Bombay *Jowar* smut was very common and they had been able to control it by sulphur dust. This method was very easy and preferable to either copper carbonate method or copper sulphate method. The treatment did not cost more than one pie per acre. Even if some of the treated seed was left over, it could be fed to cattle or converted into food.

Soil treatment was another method by which diseases which were in the soil could be controlled. This method was not commonly practised in India. because it was usually practised in commercial glasshouses Recently, they came across a very serious disease in Bombay called betel vine wilt caused by *Phytophthora parasitica* This wilt suddenly made its appearance about ten years ago and caused several considerable administrative difficulties The cultivators threatened not to pay taxes unless this disease was controlled. Fortunately this disease had since been controlled by the ordinary application of Bordeaux mixture to the soil. The cost of the treatment in Bassein near Bombay came to about Rs one hundred per acre, but growers practised the treatment as the betel vine was very remunerative

Eradication was another method of disease control. This had been practised on a large scale for the control of black rust of wheat in the United States. When this method was advocated in U. S. A., there were two schools of thought one of which believed that it was not worth while to go in for such a large expense in eradicating barberry which occurred in a wild state in the mid-western part of the United States. The United States Government voted money for that, and now although the disease had not been completely controlled, the losses from this black rust had been much reduced.

One of the primary obligations of plant pathology was to prevent the promiscuous interchange of very serious plant pathogens from one country into another. This could be done by quarantine. This pre-supposed a knowledge of the parasites and their hosts and their inter-relations. This knowledge could be gained not only by the study of the life-histories of parasitic fungi but also by carrying out disease surveys. Unfortunately, the value of disease surveys had not been much appreciated in this country and Dr. Uppal strongly felt that time had come when this work should be taken up by a Central organisation like the Imperial Agricultural Research Institute, New Delhi. As an instance of the utility of a disease survey, Dr. Uppal said that about ten years ago betel vine wilt or foot-rot appeared in the Central Provinces,

Bombay, Madras and Bengal. Nobody ever knew about this disease until they were seriously up against this trouble. If there were any disease survey, at least they would have known what the position ultimately would be. They had got another very important disease in Bombay which was destroying the banana cultivation. It was now found in a village near Poona and they had got no restrictive measures by which they could stop the spread of this disease to other areas. They had no control over the transport or spread of this disease Certain growers and traders were opposed to the principle of plant quarantine, because they thought that this was ineffective and was very cumbersome and interfered with trade Dr Uppal said that it was high time that we safeguarded our agricultural industry from foreign parasites Even if a parasite was not very dangerous in its original habitat, it might flourish and do a considerable harm when introduced in other environments

They had another disease called "Koleroga' of betel nut in North Kanara. In past years many growers did not practise control measures to the detriment of those who carried out these measures. It had now been realised that forceful persuasion to get all the growers to spray their trees was the only way to gain the desired end. They were now organising the spraying campaign on a vast scale and the ultimate aim was to cover the whole area. At present they had seven to eight thousand acres under this spray

Dr. Padwick was in entire agreement with all the points mentioned by Dr Uppal As Dr Uppal said, they had no disease survey at present in India and it was his sworn object before he left England two months ago and after a long discussion with Dr Ashby, the Director of the Imperial Mycological Institute, at Kew, to attempt, on his arrival in India, to organise a plant diseases survey. Having reached India and talked to a number of plant pathologists he had realised first how difficult a task this would be and secondly how much its need was appreciated by the workers here It had also been suggested by several plant pathologists that something might be done to form some sort of a bureau of information for plant pathology centred at the Institute at Delhi and he intended to try to organise such a bureau First of all, he intended to circulate to plant pathologists throughout the country the intention of organising such a scheme and to request them to make as much use as possible of the services available at the Institute. He felt that at the Institute they

should attempt two things in the sections with which he was concerned, first the formation of such a bureau which would provide information on the statistics of plant diseases, would have possession of an adequate collection of specimens of plant diseases for comparative purposes, would have a first class collection of type cultures, so that it might be unnecessary for Indian workers to keep sending abroad their specimens for comparison and identification, and finally perhaps at a later date would have a system whereby they could inform any plant disease worker in the country of the available literature on tho subject with which he was working. How long it would take to get all these things going, he could not say but he said that they did intend to start immediately with the survey work, but the exact mode of attack had not yet been worked out.

He thought also that a great deal of emphasis would in future have to be laid on plant pathology as opposed to mycology, because they had had a great abundance of work here and in every other country which though very interesting in itself was confined to descriptions of fungi and division of fungi into sub-species, sub-sub-species and strains of sub-species and so on and which in the end had not solved any of the plant diseases For the research work he proposed that at Delhi they should largely restrict themselves to the study of control of plant disease by cultural methods. He thought this would lend itself well to a type of work which could be applied generally throughout the country and yet would not be open to the accusation that they were invading other people's fields.

Dr. Chowdhuri said that they in the University had been working mostly on plant pathological subjects. Here in this country as well as in other countries they found that the work in plant diseases caused by Cryptogamic parasites was not taken into account. The amount of loss caused by Cryptogamic parasites sometimes was not realised at all. In Germany the loss due to all pests amounted to something like eighty million pounds sterling of which over fifty million pounds sterling loss was caused by Cryptogamic plant parasites alone. In India the plants when imported were subjected to some kind of treatment which would stop the insect pests but not the plant pests. As an instance, he said that in Bombay in the Customs Department plant materials were fumigated with hydrocyanic acid which would kill the insects but not the fungal pests. A couple of years ago he had sent a packet of plant material through the courtesy of Dr. Dunni-

cliff for fumigation. These plants were some citrus trees affected with citrus cankar and wither tip. After they had been fumigated with the usual method of hydrocyanic acid he made cultures from the fumigated material and found that there was absolutely no effect on parasites with the treatment of hydrocyanic acid. He suggested that there should be at every port a properly qualified plant pathologist who should test and carry on methods of killing these plant parasites. Plants coming from countries where certain disease was known must have certificates from that country showing that they were free from that disease. The other governments should not dump things here that would spoil our material. Every specimen coming by air or by ship must be checked and controlled.

Regarding the Information Bureau, *Dr. Chowdhuri* said that it was a splendid idea. He added that he had a talk with Dr. Padwick and they considered that the Bureau should not only supply information on the statistics of plant diseases but should keep a stock of type cultures and specimens of plant diseases with literature on the subject. It was necessary to have these facilities at the centre so that whenever any worker found a new disease he would simply write to the Imperial Mycologist asking whether any work had been done on that particular disease and if so to supply the relevant literature. He strongly supported Dr Padwick's suggestion, and agreed with him that every day they found many diseases being reinvestigated, simply because there was no organization for preserving the standard cultures for comparison. This had many times resulted in one disease being described differently by perhaps the same man This only burdened the literature with useless things and had therefore to be stopped.

Rao Bahadur Viswanath welcomed the suggestion and was glad to hear the opinion of plant pathologists in regard to the establishment of Information Bureau at the Imperial Agricultural Research Institute, New Delhi He strongly supported the idea.

The *Chairman* also supported the suggestion and assured the Board that the views of the Board had been duly recorded. He then requested Professor L. S. S. Kumar to introduce his paper on subject (d) with reference to protection from parasitic flowering plants.

Professor Kumar said that in the note (Appendix IX, F) that had been placed before the members of the Board, he had briefly examined the position with regard to the damage caused to economic crops by parasitic flowering plants. Although they were only few in number the damage caused by them was quite serious. These parasitic flowering plants could be broadly grouped into two classes: those which parasitise the aerial parts, *e.g.*, Loranthus and Cuscuta. and those which affect the root. The former usually affects large trees and bushes, shrubs and road-side hedges. Of these Loranthus was rather a serious parasite of mango. It also attacked a large number of other trees but in certain parts of Bombay Presidency it had been found that year after year the attack due to Loranthus was increasing, and it was gaining ground into mango plantations. Of the other class of parasites, *Striga* and Orobanche were important. Both these attack important economic crops. Of these *Striga* had a good many number of economic crops as its host, *e.g.*, *jowar*, sugarcane, maize, rice, *natchni*, and *kodra*. Of all these crops, it attacks *jowar* most heavily, but in some parts of India the attack on sugarcane by *Striga* is equally heavy He therefore considered that measures should be organized for systematically combating the increase of these parasites

Further he said that in addition to these cultivated crops which act as hosts in the case of *Striga* there was a large number of non-cultivated grasses which were its host. Another important point that he wanted to mention was the question of seed production. *Striga* on a single plant produced many thousands of seeds which were easily disseminated by wind. Furthermore the viability of seed was very long and experiments have shown that the seed remained viable for over fifteen years. He supported this point by giving instances.

The question of extermination was an important one. Ordinarily the method suggested was to remove the plant before it produced flowers and thereafter the seeds. But it was not so simple as it appeared. People had attempted this and yet the parasite appeared to be as serious in causing damage as ever. The reason was that the non-cultivated plants acted as hosts and fresh infection was coming every time. So unless much care is devoted and lot of labour is spent, ordinary cultural methods are not satisfactory for checking the infection from year to year.

Striga was also found in South-Africa, Sudan and some other parts of the world. Dr. Saunders of South Africa had done a considerable amount of work on the extermination of this parasite. He tried various methods: trap cropping inter-culturing, using weed killers and thick sowing of crops in order to eradicate the parasite. After trying all these methods he came to the conclusion that breeding resistant varieties of Sorghums was the only satisfactory way. In the Bombay Presidency some experiments had been conducted during the last four years in this direction. Out of fifteen varieties of *jowar* on which experiments had been carried out, two seemed to be promising resistant types

Orobanche was more or less similar to *Striga* in its various characteristics. The seed produced was also large in number and remained viable in the soil for long periods. He said that research work was being carried on on different varieties of tobacco that were grown in India and in one or two instances they had got plants which promised to give resistant types. The difficulty in their way was the inadequacy of staff.

The *Chairman* said that the subject was an important one and rather new He invited the members to express their ideas on the subject

Dr. Crowther said that in Egypt Orobanche was a serious pest of beans and certain vegetables, but no remedy was so far known beyond omitting a susceptible crop from the rotation. In the Sudan, *Striga* was prevalent and the only check resorted to was hand picking of the *Striga* shoots, a measure which had been partly successful over small areas

Dr. Choudhuri said that the blue pine in Kashmir was being killed year after year by *Arcenthobium minutissimum* and nothing was being done

Subject VI.—(e) Protection from effects of weather.

The *Chairman* requested Dr Ramdas to introduce his paper on subject (e) protection from the effects of weather.

Dr. Ramdas then summarised the important points mentioned in his note. (Appendix IX, H).

Dr. Burns said that further discussion of this new subject introduced by Dr. Ramdas would have to be postponed.

Mr. Wynne Sayer proposed and Rao Bahadur Viswanath seconded a vote of thanks to the chair which was unanimously passed. The Board then adjourned.

APPENDIX I.

Note by the Secretary, Imperial Council of Agricultural Research, dated 17th November 1937.

Statement of action taken on the recommendations of the 1st Meeting of the Crops and Soils Wing.

The attached statement showing the action taken on the recommendations made at the 1st meeting of the Crops and Soils Wing, is circulated for information Replies from some provinces and States are still awaited and will be circulated later if received in time

Statement showing the action taken on the recommendations of the 1st Meeting of the Crops and Soils Wing.

Subject and reference to pages of proceedings.	Recommendations and remarks made at the time of addressing provincial Governments and States.	Action taken.
1. Planning, technique and interpretation of field experiments. (16-21 and 49-52).	The question of appointing a standing advisory committee on this subject is under the consideration of the Council A technical Sub-Committee of the Advisory Board has been appointed meantime. The other recommendations are for consideration by the local Governments and constituent Indian States and such action as they may decide upon. The Sub-Committee's recommendations regarding uniformity in the methods of testing new varieties of cane have been approved for adoption in all sugarcane research financed by the Council and will be included in the conditions attached to future grants for all sugarcane research	The recommendation regarding a standing advisory committee is still under consideration. Replies from provinces and States are summarised below :— *Madras*—The Director of Agriculture has communicated the recommendations to the Deputy Directors and Crop Specialists for guidance *Bombay.*—A series of experiments will be taken up on the lines recommended at selected stations when the proposed standing advisory committee is established. Experimental work on the relative methods of interculture of cotton is at present being carried out on the Surat Farm [illegible] regard to planning, technique and interpretation of field experiments are being given effect so far as local conditions and circumstances permit. *Bengal*—The field experiment work is carried out according to the latest statistical methods for testing out types of crops or manures. Interculture has to be taken with two of our main crops—Jute and Aman paddy, otherwise the outturn will be poor. *Punjab*—(a) Recommendation regarding planning, technique and interpretation of results are already being followed. Wherever possible yield trials are now designed according to Fisher's randomised block method and the results interpreted by Fisher's analysis of variance method. Yield tests on a variety of crops are being carried out for at least three years on different experimental farms in the Province before the results are considered conclusive. It is not always possible to have equal numbers of replications

Subject and reference to pages of proceedings.	Recommendations and remarks made at the time of addressing provincial Governments and States.	Action taken.
		Mysore.—Replication and randomisation methods of testing and application of Fisherian technique in interpretation of results are being adopted in all crop testing and manurial experiments of sugarcane, paddy, coffee and several other crops.
		Cochin.—Manurial experiments on paddy have already been laid out in randomised blocks with six replications. Other recommendations regarding research in the *technique* of field experiments, testing new varieties of cane etc., are beyond the scope of the Department for want of staff and funds.
		Travancore.—A small Field Experiment Committee has been constituted to assist in drawing up schemes for and in laying out all field experiments. The other recommendations relating to the details of this work have been commended to the attention of the Committee which will follow them with the required modifications, if any, to suit local conditions.
		Gwalior.—On both the Central Experimental Farms at Gwalior and Ujjain the experimentation on the latest *technical lines* devised by Dr. R. A. Fisher has been started both in the crop improvement work of the Crop Botanist's section, and on the farm side comparative trials of varieties, manures, etc. The interpretation is being done statistically.
2. Soil surveys and soil analysis. (22-24 and 70-77).	The Sub-Committee's recommendations regarding the establishment of a Soil Bureau and the appointment of a Committee for defining methods of soil analysis are under the consideration of the Council. The recommendations relating to soil surveys in *relation to new irrigation* projects are for consideration by Local Governments and States. It is requested that the Sub-Committee's recommendation regarding root development studies may be brought to the notice of all research workers engaged on crop improvement schemes financed by the Council. A more specific reference will be made to	The recommendations regarding a Soil Bureau and a Committee for defining methods of soil analysis are still under consideration. Replies from provinces and States are summarised below.— *Madras.*—The recommendation regarding [illegible] has been com- [illegible] and [illegible] to [illegible] ing followed. Detailed soil surveys have been carried on in the districts of Kistna, Godavari, Malabar and the deltaic regions of Cauvery and Periyar in which all details of soil variation with reference to chemical composition of the soil were determined and mapped but these surveys could not be extended owing to prohibitive cost of conducting them. *Bombay.*—The local Government support the recommendation for the formation of a soil Bureau and the undertaking of an All-India soil survey, as these are the most desirable developments.

Subject and reference to pages of proceedings.	Recommendations and remarks made at the time of addressing provincial Governments and States.	Action taken
	this matter in sanctioning new schemes in future and it is suggested that the matter should receive special attention when research programmes are drafted.	The recommendation that no new irrigation projects should be initiated without a thorough soil survey is very necessary in the case of perennial canals or perennial sections of canals but not in other cases. In the Deccan Irrigation Circle, the Irrigation and Agricultural Departments are studying very carefully the changes which are being brought about by irrigation which cause the soil eventually to deteriorate as regards crop production. It is not necessary to appoint any scientific staff as the present staff can deal with this problem. The recommendation regarding the detailed study of root development in different soils has been brought to the notice of all research workers on crop improvement financed from the Council's funds. In practically all work on crop improvement *except purely botanical research*, studies of root development are being carried on as an integral part of such investigations Special attention will be paid to this aspect in future, in all schemes put up to the Research Council. *Bengal* —A soil survey as such is not possible as we have neither man nor money. *Punjab.*—*1.* (*a*) No large scale soil survey has yet been taken up as staff is not available for the purpose. (*b*) Thorough soil surveys are now made as part of the normal procedure in the preparation of all new irrigation projects in the Punjab. 2. (*a*) and (*b*) Root development studies are already being made on the more important crops *viz.* wheat, cotton and sugarcane. The recommendation has been brought to the notice of research workers concerned. *Bihar.*—A soil survey on the agricultural basis has been started A general unit of sampling is kept at 32 miles and in areas where the soil betrogeniety is already known, the unit is reduced to 16 miles Field examination of the soil sample is done on the spot and the following information is collected :— (1) Climate. (2) Surface feature. (3) Texture. (4) Depth of water table. (5) Colour. (6) Vegetation. (7) P. H. value. (8) Qualitative tests of carbonates. The soil is collected upto a depth of 2 ft. in three layers of 0-6", 6"-12", 12"-24". The detailed chemical and mechanical analysis

Subject and reference to pages of proceedings.	Recommendations and remarks made at the time of addressing provincial Governments and States.	Action taken.
		will be undertaken shortly. Collection of soil monoliths could not be included due to cost involved. The Government of India should be requested to consider the recommendation of the Board regarding financial assistance to the province to complete the survey.
		Central Provinces.—Detailed soil surveys of the type recommended is not possible for want of sufficient staff. The Agricultural Chemist is being asked to work out an estimate of the cost for such an enquiry. The recommendation relating to soil surveys in relation to new irrigation projects has been brought to the notice of the Irrigation Department.
		Assam.—An attempt is being made for the last two years on the root development of *boro* (Spring) paddy with reference to its development in different soil textures. The results have been summarised in a short paper which has been sent for publication It is intended to continue root studies embracing the root development of the more important paddy types. Preliminary studies regarding root development of sugarcane are being undertaken this year Standard methods are followed in soil analysis No attempt has yet been made to take up soil surveys.
		Soil aeration appears to be one of the most important factors limiting crop growth in Assam. A small beginning has been made with revenue crops such as oranges, papaya, pine apples and betel vines at Jorhat with due consideration to factors such as soil temperature, soil-water, variation in soil aeration and behaviour of weeds. But the experiments are more or less of a preliminary nature, although valuable information is indicated.
		North West Frontier Province.—No new irrigation projects are contemplated. Recommendations regarding soil surveys are being followed.
		Orissa.—Root development studies are being carried out in the flood resisting varieties of paddy.
		Hyderabad.—Proposals for the appointment of necessary staff for the study of changes in soil caused by canal irrigation are under consideration.
		Mysore.—Extensive soil survey has been conducted on an area of about 120,000 acres which has since been irrigated under the Irwin Canal. The question of resurvey of that area to find out soi

Subject and reference to pages of proceedings.	Recommendations and remarks made at the time of addressing provincial Governments and States.	Action taken.
		changes due to irrigation and the original soil survey of other irrigable and irrigated areas are under consideration. Root development studies have been made in respect of sugarcane and coffee and will be continued. Similar studies in the case of Ragi were completed long ago. Observations on the root development of cotton are in progress. *Cochin.*—No new irrigation projects are contemplated. *Travancore.*—There is no new major irrigation project now under consideration in Travancore. The attention of the Bio-Chemist has been drawn to the recommendation regarding the periodical examination of soils already under irrigation. Provision will be made for root development studies when a crop improvement scheme financed by the Council is in operation in Travancore. *Baroda.*—An Agricultural Chemist has recently been appointed whose chief duty will undoubtedly lie in the analysis of soils and well waters of the State. *Bhopal* —Work on soil has been commenced and root development studies are being carried out at the Government Agricultural Farm. *Gwalior.*—As per recommendations the soil surveys in relation to new irrigation projects are being arranged for through the Chemist and the propaganda staff engaged in the new irrigation Project areas. The results will be known when the work is completed
3. Soil Amelioration. (25-30 and 77-82).	The Sub-Committee's recommendations are commended to local *Governments* and Indian States.	The root development studies are also on the programme of the Crop Botanists wherever it is thought necessary. The type of erosion in the ceded districts of the Presidency though serious does not actually create "ravines", the undulating nature of the country gives rise to water-courses along the valleys. The ravines which are formed in other provinces are not to be seen in Madras, except in certain districts where they are formed in small isolated areas, mostly in hilly tracts. In the Deccan Districts soil erosion is prevented by contour ploughing and the building of stone embankments. In sloping lands, terracing and providing bunds mitigate the loss of soil. The land is kept fallow to the shortest minimum period when it is left in a rough condition. Crops are planted on nearly contours and the surface water is led into properly constructed drains. Organised rotation of crops and application of cattle manure in large quantities are advocated. In the

Subject and reference to pages of proceedings.	Recommendations and remarks made at the time of addressing provincial Governments and States.	Action taken
	(iii) The Imperial Council of Agricultural Research may be invited to formulate a scheme for giving effect to these proposals."	
8. Fruit industry (89-96).	The following resolutions passed by the Board are commended to the notice of Local Governments and Indian States :— I. "That this Board desires to emphasise the value of fruit growing to Indian agriculture. It notes that the Government of India through the Imperial Council of Agricultural Research is financing both extensive schemes of fruit research and comprehensive marketing surveys. It also notes that in some provinces the Agricultural Departments have been able to do a good deal to aid fruit growers by research demonstration, the provision of nursery stock and assistance in organisation. It desires to emphasise the importance of Agricultural Departments being placed in a position to render adequate assistance to fruit growers by the provision of expert staff and funds to ensure the provision of such facilities as described above. II. That this Board recommends that special courses of training in scientific fruit and vegetable growing be started in all the provincial Agricultural Colleges III. That this Board would like to draw the attention of Local Governments to the Advisability of registering all nurseries producing fruit trees for sale to the public".	*Madras.*—The recommendations are under consideration. *Bombay.*—Owing to the prevailing financial stringency, the question of strengthening the horticultural staff has been postponed. *Special course of training in fruit and vegetable growing* —This is being done already at the Poona Agricultural College. A scheme regarding the registration of nurseries has been prepared by the Horticulturist to Government and will be brought into force in the near future. *Bengal* —The recommendations are in operation *as far as they are applicable* *Punjab* —The Fruit Section of the Department, though started in 1920 has made considerable progress It has got 6 gazetted Officers and 11 technical Assistants engaged on (*a*) Teaching, (*b*) Research and experimental work and (c) Advisory and district propaganda work Under *Teaching*, eight different courses are given to various classes of people at different times of the year. These are very popular and well-attended. Under *Research*, work is being done on the preparation of many kinds of fruit juices as squashes, preparation of jams, jellies, chutneys, candied fruits, drying fruits and curing dates A fruit canning factory has also been constructed and is being used for the preparation of canned fruits on a semi commercial scale. Under *Experimental*, *work is being done* on citrus root stock investigations, grape-vine hybridization, root pruning, manuring, bark ringing branch pruning, pollination studies, methods of packing and storage, etc Under *Advisory and propaganda* work, about 300 gardens were visited by the staff during 1935-36. A Provincial Co-operative Fruit Development Board has been started which has got a membership over 400 Amongst its activities, a Fruit Journal has been started and Co-operative Marketing is being organised. Leaflets on fruit development are distributed free. Fruit surveys were made in 1927 and again in 1933. A provincial fruit show is held every year in Lahore, with similar shows, at other places in different seasons.

Subject and reference to pages of proceedings.	Recommendations and remarks made at the time of addressing provincial Governments and States	Action taken.
		Bihar.—Since the introduction of the Fruit Research Scheme, the recommendations of this Board are being adhered to as far as possible, especially classification of fruits, survey of fruit growing tracts, supply of profitable varieties of fruits of economic importance. Short courses are also being held on fruit preserving and preparation of drinks and syrups. Owing to paucity of funds and lack of training facilities, it has not been possible to consider the question of holding special courses of training in scientific fruit and vegetable growing
		Central Provinces.—The staff in citrus culture is provided by the Imperial Council of Agricultural Research. A horticulturist is needed but he cannot be entertained for want of funds. Nurseries recognised by the Agriculture Department are being registered by the Deputy Director of each circle. A scheme is being drawn up for a special course of training in Scientific fruit and vegetable growing
		Assam.—The question of starting a fruit station in the Khasi hills to work on citrus fruits, especially orange, is under consideration. Work on the improvement of orange is being conducted at Bakitar Farm, Haiflong hill and Khanapura (Gauhati). Attempts are being made to combat the yellowing (not die-back) disease of orange. Preliminary trials have been made in canning and preserving various fruits, vegetables and in making unfermented fruit juice, syrups, etc. For lack of funds, the work has been discontinued. Real *initiative has recently been given* to growers of pine apples by distribution of suckers of superior varieties (exotic) and with necessary instruction regarding their cultivation. Efforts have been made for better marketing of fruits and the railway freight thereof has been reduced to quarter rate for pine apple. The fruit garden at Shillong is mainly devoted to deciduous fruits such as apples, pears, peaches and plums. Grafts are being distributed in Khasi and Jaintia Hills. The plums and peaches of Shillong have a future prospect. Attempts are being made to improve the bee-keeping especially in the hills. A number of fruit Nurseries have recently cropped up. There is a great scope for the Nurseries

Subject and reference to pages of proceedings.	Recommendations and remarks made at the time of addressing provincial Governments and States.	Action taken.
		North-West Frontier Province.—The development of the fruit industry is receiving all the attention that limited funds and staff will permit. The registration of nurseries is not considered practicable as nearly every orchard owner is selling nursery stock.
		Orissa.—The Department is fully alive to the value of fruit-growing. A scheme for a fruit farm in Koraput is under consideration. Another scheme has been submitted to the Council. A third scheme of a farm and the appointment of a Horticulturist are under consideration.
		Mysore.—There is a special Department of Horticulture in Mysore to facilitate the encouragement of fruit growing in the State. A scheme sanctioned by the Imperial Council of Agricultural Research will come into operation this year.
		Cochin.—Propaganda to increase the fruit industry is being done.
		Travancore.—The Agriculture Department maintains a Fruit Farm at Cape Comorin which has been doing pioneer work for the cause of fruit cultivation in the State. Proposals for increased facilities on this farm are under consideration. Practical training in elementary horticulture is being imparted in the Agricultural Schools of the State
		Baroda.—A Horticulturist has been appointed Surveys have been made of the likely fruit producing areas of the State and training is being given in the Agricultural Institute. All nurserymen of experience and repute who have expressed willingness to be registered have been so treated.
		Bhopal.—Work has been commenced on fruit growing in the State.
		Gwalior.—This activity is being done by our propaganda staff, through whom fruit plants of economic importance are freely distributed to selected cultivators.
		Patiala.—The Nursery Section of the Garden Department undertakes the propagation of the best varieties of fruit plants.

Subject and reference to pages of proceedings.	Recommendations and remarks made at the time of addressing provincial Governments and States.	Action taken.
9. Agricultural Marketing (52-58).	The following resolutions were passed by the Board :— "I. That in the opinion of this Board the scheme for the improvement of marketing agricultural produce recently put into operation by the Government of India and outlined in the Government of India's Resolution No. F. 16-M/34, dated the 10th January 1935, is calculated to be of the greatest benefit to Indian agriculture. II. That this Board is also of opinion that the organisation described in the Government of India's Resolution of January 1935 is well designed and the programme of work suitable to immediate needs.	The Agricultural Marketing Adviser reports that due attention is being paid to the collection of adequate statistics both by the Central and local marketing staffs and efforts are being made with a view to the improvement of the publications concerned The question of the forecasts and estimates of yield in respect of wheat is receiving the consideration of the Wheat Committee. With a view to making complete the publication entitled "The Monthly Statistics of the Production of certain Selected Industries" published by the Director General of Commercial Intelligence and Statistics, certain wheat mills were approached for securing their co-operation in the matter. The aforesaid publication does not give the output of rice mills, nor is the number correctly indicated in the publication entitled "Large Industrial Establishments in India" These matters have been referred to the Director General of Commercial Intelligence and Statistics. Negotiations are also in progress with regard to the amplification of the rail-borne trade statistics published in the Indian Trade Journal.
	III. That this Board considers it very important that the collection of adequate statistics should be borne in mind by the new marketing section in carrying out its scheme of work." The first two resolutions call for no action. The third has been brought to the notice of the Agricultural Marketing Adviser to the Government of India for necessary action.	It is proposed that, apart from the addition of about 20 more articles to the list, the railway classification should be so revised as to be of more practical value for all concerned and that freight rates for certain important commodities between chief centres of trade should be published
10. Influence of Hydro-Electric power or agricultural development (65-67).	The following resolution of the Board is commended to the notice of Local Governments and Indian States :— "That this Board views with appreciation the success of the Hydro-Electric scheme in the rural areas of the Western United Provinces and commends it to the notice of other Local Governments."	*Madras.*—The need for supplying power at cheap rates is kept in view *Bombay*.—There is little scope for hydro-electric development for agricultural purposes in this Presidency. *Bengal.*—The recommendations are in operation as far as applicable. *Punjab*.—Wherever Sub-Soil water is suitable for irrigation, the use of power from the Uhl river Hydro-Electric Scheme is recommended to zamindars for lifting

Subject and reference to pages of proceedings.	Recommendations and remarks made at the time of addressing provincial Governments and States	Action taken.
		water if conveniently available Demonstration of electrical appliances are arranged at the time of "Farmers' Weeks" organised by the Agriculture Department to explain the advantages of pumping and cane crushing by electricity. The Agricultural Department is also using hydro-electric power on some of its farms.
		Bihar.—The recommendations are under consideration.
		Central Provinces.—Conditions in the Province are not favourable to the development of hydro-electric work.
		Orissa.—No Hydro-Electric scheme for the development of agriculture has been considered
		Mysore.—Owing to the special facilities given by the Mysore Government to encourage the use of electric power by agriculturists for the installation of irrigation pumps a large number of irrigation pumps have been installed in the State
		Cochin—The subject will be considered when hydro-electric power is available.
		Travancore.—A large hydro-electric project is under construction at Pallivasal. The plans include provision for supplying cheap electric power for agricultural operations
		Baroda—Considerable attention has been paid to the possibilities of developing electric power for rural needs A number of wells have been electrified around Baroda and one company at Kadi has been given a substantial loan in order to enable it to develop its rural power

APPENDIX II-A.

Notes on Subject II (A review of the theory and practice of manuring in India, with suggestions for the future: (a) with reference to farmyard manures and composts, (b) with reference to green manuring, and (c) with reference to manuring with artificial manures).

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The terms of reference are so wide and the data to be dealt with are so large and varied that it is impossible to discuss the available material without greatly exceeding the permissible limits for a note of this kind The discussion on the available data will, of necessity, be restricted to the consideration of the salient points of the subject matter under consideration

The theory and practice of manuring in India had its origin thirty years ago, in the then prevailing ideas of chemical treatment of the soil as postulated by Liebig and Lawes and Gilbert, who originated the fertiliser industry. According to these ideas one had only to make a chemical analysis of the soil and to make good the deficiency by the addition of minerals indicated by analysis to maintain the fertility of the soil. Experiment and experience has gradually changed the ideas and the whole problem has been slowly but steadily been clarifying after passing through the realms of different branches of chemistry and biology and has in recent years assumed a new outlook. The soil processes and the carbon and nitrogen cycles involved are becoming clearer and mineral fertilisers have begun to fall in their place as important but not all important The new outlook includes in its horizon, the direct and indirect effects of organic manures on crop growth, the necessity for utilising organic waste materials and a consideration of plant growth in terms of the cycle bacteria plant-animal-bacteria.

A number of experiments have been carried out in different parts of India. 300 experiments, reported in journals, bulletins, and annual reports and which appeared to have been carefully conducted have been selected Of these 43 experiments were conducted in dry or precarious rainfall tracts and yielded results of an erratic nature These are, therefore, eliminated The remaining 257 have been retained for further examination because they did not suffer from the limitations of water supply. There were either irrigation facilities or the rainfall was over thirty five inches The following statement summarises the results

—	Total number of experiments	Experiments with significant increase in yield	Experiments with not significant increase in yield.	Experiments with negative results.
Farmyard manure with or without artificials	72	37	32	3
Oil cakes	13	11	6	1
Oil cakes + artificials	11	7	4	..
Green manure with phosphates	10	8	2	..
Green manure with nitrogen and phosphates	18	10	8	..
Bone meal	15	12	1	2
Fish manure	3	2	1	..
Total	147	87	54	6
Per cent on total	..	59 2	36·0	4·8

—	Total number of experiments	Experiments with *significant* increase in yeild	Experiments with no *significant* increase in yield	Experiments with negative results
Sodium nitrate	8	4	4	..
Ammonium sulphate . .	34	17	15	2
Phosphates	17	11	5	1
Nitrogen with Phosphates	51	36	13	2
Total .	110	68	37	5
Per cent on total . .	..	61·8	33·6	4·6

The crops experimented with were paddy, sugarcane, cotton, tobacco, potato, groundnut, maize, *jowar*, wheat and jute. The most responsive crop to manurial treatment was paddy and the least responsive was cotton. The following statement show the differential *response* by the two crops.

—	Total number of experiments	Experiments with significant increase in yield	Experiments with no significant increase in yield	Experiments with negative results
Paddy.				
Farmyard manure	8	6	2	
Oil cakes	5	3	2	.
Oil cakes + phosphates . .	2	2		.
Green manures . . .	4	4		.
Green manures with phosphates	17	9	8	
Bone meal	11	9		2
Fish manure	2	2		.
Total .	49	35	12	2
Sodium nitrate . . .	3	.	3	
Ammonium sulphate .	8	4	4	
Phosphates	7	7		.
Nitrogen with phosphates .	28	23	4	1
	46	34	11	1
Cotton.				
Farmyard manure . . .	18	7	10	1
Oil cakes	4	3	1	
Oil cakes with other artificials .	7	4	3	
	29	14	14	1
Sodium nitrate . . .	2	1	1	.
Ammonium sulphate . .	9	2	7	
Phosphates	7	1	3	1
Nitrogen and phosphates .	3	1	2	
	21	5	13	1

These experiments having been conducted at several stations and in different years do not give a picture of the relative merits of organic manures and artificial fertilisers. There have been very few really good comparative experiments spread over a number of years. Hendry (*Agricultural Journal of India*, 192[illegible], 3[illegible]) carried out such experiments for ten years. He applied different manures and fertilisers for five years and then measured their residual effects during another period of five years. The results as reported by him are given in the statement below:—

	Per cent increase over control (5 years)	Residual effect per cent increase during 5 years over

The biggest limiting factor, as would be expected, is the supply of moisture in the soil. If this is lacking, manuring does more harm than good. The following data for *jowar* crop on similar soils but with differences in rainfall explains this (*Madras Agric. Journal*, Vol 20).

	Per cent increase or decrease over control in the season in which the crop was manured.	
	Kolipatti. Rainfall 30 *inches.*	Hagari. Rainfall 19 *inches.*
Oil cakes	+28	—20
Calcium cyanamide	+58	—26
Ammonium sulphate+super	+71	—31

The concentrated manures are least effective and even harmful in localities with precarious rainfall or moisture supply. Early in the life of the crop there will be vigorous growth and as a consequence the moisture supply is so exhausted that it is inadequate at the seed setting stage. This is evidenced by the straw/grain ratio The effect of bulky organic manures like farm yard manure, composts and green manures is less than the intensity of the effect of concentrated manures, by improving the moisture conditions.

The broad inference that may be drawn from the data presented is the general usefulness of organic manures and their importance in any system of manurial treatment for any crop. Two points are to be considered. The one is with regard to gross yield and the other is with regard to the extent to which manuring can be done with profit. Whether manuring can be done with profit or not, depends naturally on the cost of manuring and on the price level of the commodities produced and to this point attention has been directed in certain of the investigations in the past and is likely to be directed still more in manuring investigations in future

In regard to gross yield there have been several cases in which complete manuring with chemical fertilisers alone does not produce a maximum yield Farmyard manure and other organic manures alone have not always given the maximum yield It is only by the combination of both that the best yield can be obtained The greatest returns are generally obtained by nitrogenous manures although the action of phosphates is considerable and in many instances combination of nitrogen and phosphate has given higher yields than with nitrogen alone The ratio of grain to straw varies with the nature of manuring and is the highest with cattle manure (Norris *Mem. Dept. Agr.* Vol. 9)

	Ratio grain to straw
No manure	13 7
No phosphate	14 3
Phosphate	19 6
Cattle manure	23 7

There is a very strong suggestion that organic manures assist the utilisation of chemical fertilisers Likewise, if the action of mineral fertilisers is taken as constant and is compared with that of organic manure either alone or in conjunction with them, it is seen that organic manure availability is stimulated by the action of the fertilisers.

The following illustrate the point.

Manganallur Experiment Station, Paddy.

	Yield per acre.
Green leaf at 3,500 lbs. per acre	2,033
,, + 1 cwt. Ammonium sulphate	2,433
Ammonium sulphate 1 cwt.	2,073
No manure	1,653

Palm Experiment Station—Sugarcane.

	Per cent. increase over standard.
Oil cake 50 lbs. N	Standard
Oil cake 100 lbs N.	30 9
Cake N 80 lbs mineral N 20 lbs	41·6
Cake N 60 lbs mineral N 40 lbs	56 5
Cake N 40 lbs. mineral N 60 lbs	38 2
Cake N 20 lbs. mineral N 80 lbs	49 6
Nil mineral 100 N lbs	40 5

In taking up a comparative study of the behaviour of manures and fertilisers, it is natural to begin with those containing nitrogen for the reason that besides being the most important fertilising element it is also the most expensive

Oil cakes and other organic manures are generally more beneficial to soil tilth than mineral fertilisers Besides this, these manures have to undergo bacterial changes in the soil before they are ready for the plant The plant is in consequence fed more steadily and continuously without being presented with excess of nitrogen at the earlier stages of crop growth, as is the case with mineral nitrogen. Whatever stimulation or check, due to changes in and outside the soil, that may occur to the plant, the effect will be precisely the same on the bacterial changes concerned in the breaking down of the complex substances contained in organic manures into simpler substances for use by the plant A plant supplied with nitrogen in this way grows normally is healthier and gives rise to produce of higher quality than the one with an over surplus and is in a rush in its younger stages of growth The dilution of organic fertilisers with small quantities of mineral fertilisers is primarily to help the micro-organisms than for the sole use of the seedling.

Here then is the advantage of organic manures over fertilisers for the majority of Indian soils Really significant increases can be brought about by better and rational crop feeding policy and this ensures in the produce the quality required for seed and for food

Newer knowledge is growing in regard to the action of organic manures in the direct nutrition of crop plants The observation made ten years ago (*Mem Dept Agric* 1927) that *crop plants obtain substances akin to vitamins from the organic* matter in the soil has been confirmed by workers in other countries *Nature* July 24, 1937, *Proc Roy Soc* June 1937) This means that mineral fertilisers valuable as they are cannot altogether replace organic manures and unless an adequate supply of farmyard manure compost oil cakes green manures is available crops yields suffer both in quantity and quality

ordinarily is to reserve the better soils for cash crops and to concentrate such supplies of available manure upon these portions of land at the expense of areas of lower fertility and of the food crops grown thereon. This will naturally lead to an exaggeration of the original differences in fertility. If any alteration is to be made in this practice, it should be in the direction of diverting part of the supply of organic manures from the so called cash crop soils to the relatively poorer food crop areas and the introduction of the method of making up the deficiency by the use of small quantities of fertilisers Further experimental work should be in the direction of determining the minimum requirements of organic manure consistent with quality and quantity of yield.

The fertility of a soil depends primarily on its content of organic matter. It is necessary to improve methods of cultivation and implements in general use with one specific object among others, namely the formation of a deeper layer of fertile soil in a condition of good tilth such as will conduce to the development of a deeper and more extensive root system. Improved cultivation of this type cannot do anything but good, but on the other hand it is possible to employ mistaken methods of varying it in the direction of multiplication of ploughings which will inevitably lead eventually to disastrous results. Soil humus, far from being an imperishable substance, is rapidly attacked and destroyed by natural processes continually in operation. These processes, are partly chemical and partly biological but both these classes of action are strongly activated by stirring the soil, which promotes aeration and therewith the numerous oxidising processes, resulting partly in formation of carbon dioxide and partly nitrates.

The obvious effect of this intensive cultivation is an improvement in the yields of crop at the expense of reserves of plant food and destruction of humus in the soil Information should be obtained on (1) the conditions that make for excessive destruction of organic matter and (2) on the possibility of retarding the destruction of organic matter in the soil.

APPENDIX II-C.

Cattle dung and composts.

(R. G ALLAN, *Commissioner of Agriculture, Baroda*)

The general outcome of experimental work throughout India has been to establish the essential value of heavy organic manures and to emphasise that quite apart from their nitrogen or mineral contents the direct addition of organic matter provides something which equal quantities of mixed fertilizers cannot.

It is also equally certain that except in relatively rare cases economic conditions demand the utilization of a great part of the more natural supply of this organic manure, *i.e.*, cattle dung, as fuel Were it not for this, with its enormous cattle population there would exist in India more than sufficient, were it conveniently voided and stored for the full manuring of all irrigated or *kharif* crops i e., those which show the most adequate return.

An alternative form of fertility of somewhat similar origin i e, human excreta, after effective decomposition, so heavily used in China and Japan, has been advocated and has been shown to be as effective, if not more effective than cattle dung, for the last 30 years, but all the talking or propaganda in favour of its manufacture in the village and use have led to nothing and are not likely to do so

As far back as 1922 Ritchie drew attention to the amount of vegetative waste, carelessly treated field weedings and the like, which went abegging on a farm and showed that by collection, storage and decomposition in the ordinary way of compost making this would provide a manure but little short of cattle dung in effect, while I believe composting of vegetable waste has for years been a regular practice at Dacca It was not however till Howard at Indore and Fowler at Bangalore began to work out a technique which introduced the principles of artificial farmyard making as by adco, but utilized the local products of farm, urine earth and ashes, that serious attention began to be given to the possibilities of these methods or variations thereof as means of making good that essential and unavoidable loss created by the fact that cattle dung in India has an alternative economic value—fuel

There is no intention in this note to discuss the relative merits of the Indore and Bangalore technique as in the writer's opinion each under certain circumstances has its merits, though possibly from a general farming point of view he is inclined to favour the former or variations based thereon

Experience however has shown, both on the farms in the United Provinces and latterly in Baroda that systematic attention to the utilization of all waste, together with the cultivation of leguminous material as by catch crops of land temporarily otherwise fallow and the systematic planting of *Dhaincha* on patches of waste land, paddy bunds and the like their effective collection and treatment as in the Indore continuous method, or after storage in a prepared state during the dry season with making and turning in the rains does result in enormous additions to the amount of available organic manure of anything between three times and six times the quantity previously available when the only attention given was the daily removal of all the dung and uneaten fodder and its dumping into a manure pit

Of the two methods "the continuous" whereby what is to hand in the way of waste, adopting the Indore technique or some variation thereon is converted into manure throughout the year if water is easily available is probably the better; but given a sufficiency of rain in the monsoon the periodic so termed as it consists of preparing stacks of litter duly treated during the dry season and leaving all the turning and making till the rains is easier especially in the absence of easily secured water, and can result in first class manure by the close of the monsoon This last however does imply that the main manuring of the year is to be done in the cold season, as for instance for irrigated wheat sugarcane and cold season market garden crops If it is a case of manuring before the rains as would apply in a cotton country, the year's stock collected in the dry season prior to one monsoon, and made in that monsoon has to stand by for some months before application, occupying space, even if partially protected from losses by a surfacing of earth

Both processes however demand certain essentials by the party who adopts them viz., time to time collection and carting in of waste which does not provide much difficulty, as there is usually spare time and labour on any farm; the preparation of a loose earth floor and the maintenance, advisable though not absolutely

Under dry rabi crop conditions as on the heavier black soils two factors render it purely speculative (1) the fact that August may be so wet as to prevent ploughing without damage of the tilth thus causing delay and cutting down the time (2) The expectation of 12" rain after inversion, unless done very early in August, is not to be depended on and there is no irrigation to make good.

Green manuring before wheat as fundamentally safe is restricted to alluvial soils protected by irrigation. The expectation is from 12 to 15 per cent. increase.

On the black soils there is only on occasion a definite increase on the following wheat crops. It is only reasonably possible in the tracts where the rainfall exceeds 40" and if a lucky break occurs at the end of July or early August. Otherwise it is better to let the next wheat crop have the benefit to the Sann stubble and cut the Sann for compost purposes. The only safe way of using green manure to improve rabi land of this kind is to sow and invert it before gram, as in this case it can be done later without affecting the gram crop and is effective in (a) improving this crop (b) improving next year's wheat, provided that after inversion 5" to 6" of rain are received

Three important staples thus under certain conditions benefit profitably, from resource to direct green manuring. Whether the practice is likely to be popular in any given tract where it is feasible is largely dependent on whether or not *there is any likelihood of an alternate crop which will bring in a more direct return.* Thus in the Western United Provinces the possibility of growing cotton reacts against green manuring, though at times methi, sown in between the cotton and ploughed in after cotton picking provides something of this kind for the cane crop. In irrigated areas in Baroda in which wheat is a common crop, bajri offers the cultivator some clear return if grown in the monsoon In other tracts early paddy is more popular than Sann before cane and the only possibility is a very early sowing of Sann on irrigation in the hot weather accompanied by transplanting of the paddy started on the seed beds in the hot weather

In so far as its application to land normally under dry kharif crops which appear in areas of lower rainfall, like cotton and juar, no very definite progress has been made in the matter. The only instance of which the writer is aware in which leguminous crops are introduced as a practice in between rows of cotton for the express purpose of inversion is in Gujerat The work at Surat has shown that a substantial amount of fertility can be obtained by increasing the distance between the rows of cotton to 5' or 6' and sowing in *Dhaincha* between these two have this buried 4 5 weeks later. In the better soils farmed by the more progressive *farmers near Navsari in Baroda* in a very fair number of fields one now finds the cotton spaced to 5' 6' and interrowed with urid grown solely for the purpose of green manuring In these urid is uprooted by hand and laid along each side of the cotton line, getting partial covering from the earth worked up along the lines where the urid was originally sown

The work at Surat would indicate that a more effective practice might be the broadcasting of *Dhaincha* over a whole field, its inversion in the normal way being followed by the sowing of juar—a month or so after the normal time or by the sowing of a semi rabi variety It cannot however be said that this has as yet been adopted as field practice by any appreciable number of farmers It must however be realised that the conditions in which cotton is grown on the heavier soils south of the Narbada or even immediately north of it are very different from those which pertain over the Deccan, Kathiawar and North Gujerat It might however appear a *possibility* in the irrigated cottons of Northern India and Sind, if not already in evidence Gujerat experience appears to indicate that the wider spacing of Herbaceum does not lower the yield on any reasonably fertile soil while the bringing of green manure on top of this definitely increases this

The only remaining example of the use of green manuring as an aid to fertility is to be found in orchard cultivation where the growth of a crop of Sann and its inversion as at times done in the monsoon, when the orchard is still young, both benefits a cold weather vegetable crop, if taken and the future success of the orchard This is a practice which costs but little appears one which could be vigorously advocated in many *of the recently planted orchards now coming into being* with the increasing interest in fruit culture.

APPENDIX II-E.

Recent advances in green manuring practice.

(K. R. NARAYANA IYER, *Director of Agriculture and Fisheries, Travancore*)

In Travancore green leaf manures are now generally being ploughed into the puddled soil before sowing tha paddy seeds or transplanting the seedlings When the seedlings establish themselves a top-dressing of a nitrogenous manure like ammonium sulphate or a combined nitrogenous and phosphatic manure like ammophos is given. Studies in tha laboratory on the course of absorption of nutrients by the rice plant showed that it took up most of its requirements during the first few weeks of its growth. It was therefore considered desirabla to ascertain if green leaves as they are now applied decomposed sufficiently quick to yield all their nitrogen to the crop during tha staga when it rapidly absorbed this nutrient.

Experiments were started with tho leaves of Vaha (*Albizzia lebekk*), Pongam (Pongamia glabra) and Portia (Thespesia populnea), Cuttings of thesa at tha stage of maturity at which they are generally taken for manuring were obtained and their total nitrogen determined. Samples were then mixed up with paddy soil end allowed to decompose in flasks under paddy land conditions In another series of flasks under exactly similar conditions, manures ordinarily used for top-dressings like ammonium sulphate and ammophos were mixed up with tho green leaves at the time of introducing them into the flasks The progress of decomposition of the manures in both the series was carefully noted for a period of three months It was found that the rate of decomposition of the green leaves varied with the *total nitrogen content of the manures employed, satisfactory progress being* observel only in those flasks in which it was not less than 1 8 per cent All the green leaves experimented with contained only less than 1·0 per cent. nitrogen.

These experiments suggested that the *present practice of applying green* manure alone in the initial stage was not satisfactory. To get thá full benefit of the leaf manure it should be reinforced with a dose of nitrogenous manure large enough to raise the total nitrogen content to 1·8 per cent. It therefore appeared to be advantageous to combine in one early application the green leef manure and the nitrogenous manure now generally reserved for top-dressing at a later stage To test out this inference a series of experiments were conducted in pots in the potcultnre house on the *Valsiramindan* variety of paddy Each treatment was quadruplicated and the yields were of the following order —

No manure	100
Green leaf manure alone	127
Green leaf manuro+ammonium sulphate simultaneously appliad	204
Green leaf manure at nna stago+ammonium sulphate top-dressed three weeks later	190

In view of the advantages noticed as a *result of the* combined application, the experiment deserves to be tested out on a field scale under a variety of conditions.

APPENDIX II-D.

The preparation of composts from waste materials.

(K. R. NARAYANA IYER, *Director of Agriculture and Fisheries, Travancore.*)

A great deal of work on the preparation of composts from garden sweepings, street refuse, etc., has been done in Travancore The first experiments were in pits wherein the materials were stacked in successive layers each layer being moistened with an emulsion of cattle manure A small quantity of bonemeal was also scattered over each layer before the next layer of raw material was added. Finally the pits were covered with a layer of earth about six inches deep and were protected from sun and rain by means of thatched sheds The pits were opened after a period of three months, the contents thoroughly mixed up and moistened and left as such a further period of eight weeks or so with occasional moistening and stirring. The final product obtained by this method was not in every instance quite satisfactory, not being quite homogeneous in texture The chief mistake often committed by the ryots in adopting this method was the compacting of the layers by pressure which made conditions anaerobic and which *consequently delayed decomposition* Although covering the top-layer with earth helped prevention of loss of moisture by evaporation to some extent it interfered with active decomposition. There was also not enough rise of temperature in the pits to kill weed seeds or infections organisms in the raw materials used

An improvement in the method of preparation of this manure on the lines suggested by Dr Fowler of Bangalore has been tested with remarkable success by introducing a process of activation. Briefly, this method consists in stacking the material on the open ground moistening it with cow-dung solution to which a little bonemeal is added and then stirring it thoronghly once every week In the course of about 3 weeks' time the material begins to decompose when one half of it is removed to form a 2nd heap while fresh material is added to the first heap to make it up to its original size *In* another 3 weeks' time one-half of this 2nd heap which has further decomposed now is removed to form a third heap and a corresponding quantity of the first heap is removed to the 2nd heap and so on fresh materiel being always added to the first heap. Herein we have a series of heaps with the raw material at one end and the finished product at the other The advantages of this improved method are,—

1. the decomposition is essentially aerobic;
2. there is high rise of temperature during the decomposition—as high as 60°C enough to cook up all pathogenic organisms and weed seeds;
3. the resulting product is quite uniform and thoroughly homogeneous;
4. the process is continuous and the finished product which is of a very high quality becomes ready once in every three weeks' time or so

The principles underlying this improved method have been quite successfully adopted in the preparation of compost from the nightsoil and city refuse of the municipal towns of Quilon, Trivandrum and Nagercoil in Travancore

Experiments conducted with nightsoil compost and ordinary cattle manure on different varieties of paddy under identical conditions have shown that the compost in every case gives higher yields both of grain and straw than cattle manure, the crop yields being of the following order —

Treatment.	Grain.	Straw.
No manure	100	100
Cattle manure	163·8	110·4
Nightsoil compost	248·0	174·4

There is considerable demand for the compost and it is very popular with the ryots

of the preparatory tillage operations and paddy seedlings were transplanted. The crop yields are given below.

Serial No.	Materials used.	Quantity applied per acre in lbs.	Average grain yield for 4 years. in lbs.
1	Phyllanthus leaves	4,000	2,351
2	Tamarind leaves	4,000	2,032
3	Palmyra leaves	4,000	1,860
4	Vrali leaves	4,000	1,090
5	Peranda stems	4,000	1,680
6	Plantain stems	4,000	1,802
7	Check plot	*Nil*	1,500

An examination of the results given in the above statement shows that the leaves and stems of all these different materials have considerable ameliorating effect on alkali injury, the leaves of Phyllanthus (Emblica officinalis) ranking first

Experiments with sulphur and sour leaves deserve to be repeated on a larger scale and under a variety of conditions in other parts of India also where the problem of reclaiming alkali soils is no less serious

APPENDIX II-F.

Recent advances in alkali land reclamation—certain experiments in Travancore.

(K. R. NARAYANA IYER, *Director of Agriculture and Fisheries, Travancore*:

There are large areas of alkali soils in South Travancore lying more or less in a barren condition now. The defect with them is that they possess an abnormally *high PH., owing to the presence of toxic concentrations of sodium carbonate and* sodium bicarbonate. The first experiments with these soils were designed to wash off the injurious salts by irrigating the lands copiously with non-alkaline water, and to drain them away. This method did not prove successful because after partial leaching the soils became deflocculated and impervious to the penetration of any further quantity of water. The sodium ions reacted with the clay and humus in the soils forming sodium clay and sodium humates Further leaching was ineffective and deleterious concentrations of alkali salts always persisted in the soil.

On analysis, these soils were found to contain a fairly large percentage of calcium This suggested the possibility of replacing the injurious sodium ions in the soil with the beneficial calcium ions All that was required was an agency to increase the solubility of the calcium minerals. Dr. Lipman had suggested some years ago that the biological oxidation of elemental sulphur might effect this change, converting the sodium clays and sodium humates into normal calcium clays and calcium humates

The process was first tested in the Laboratory The soil which contained 150 p. p m. of carbonate and 1100 p p m. of bicarbonate was treated under aerobic conditions with elemental powdered sulphur in three different proportions. It was found that the addition of sulphur at the rate of half a ton per acre resulted in the complete disappearance of the carbonates and reduction of bicarbonates to a very considerable extent

The results of these experiments were tested out under field conditions in 5 cent. plots to which powdered sulphur was applied at the rate of half a ton *per acre*, a few plots serving as controls. To promote aeration and oxidation of sulphur the soil in the plots was ploughed up every fortnight When crops were raised in these plots the yield from the sulphur treated plots was almost double the yield of the control plots The experiments were repeated for a further period of 3 years and thereafter only cattle manure was applied to both the experimental and the control plots The experimental plots bear an excellent crop of paddy every year, while in the check plot crops fail very badly in patches The residual effects of sulphur were found to be lasting.

Although these experiments proved quite successful it was thought that they were a little beyond the reach of ordinary and poor ryots. Experiments were therefore initiated to see if these lands could be successfully reclaimed for cultivation by using cheap and easily available materials like different kinds of sour leaves and stems which would neutralise alkalinity, at the same time enhance the humus *contents of the soil.*

The following materials were used for the experiment :—Phyllanthus leaves (Emblica officianalis) Tamarind leaves (Tamarindus Indica) Palmyra leaves (Borassus flabellifer), Vrali leaves (Dodonea Viscosa) Plaintain stems (Musa Paradiscia) and Peranda stems (Vitis quadrangularis)

The experiments were carried out in five cents plots and each treatment was

to collect all the waste organic matter on the farm and turn it into compost The following simple conditions for the preparation of compost manures have been found to give good results :—

(a) Suitable composition of the waste material for composting. It has been found that for proper fermentation it is essential that there should be more pentosan than lignin in the material.

(b) Suitable supply of some readily available nitrogenous compound, so as to furnish an easily available food supply to the organisms which decompose cellulose

(c) An adequate supply of moisture

(d) An adequate supply of air inside the pit, depending upon the nature of the raw material and its degree of compactness

(e) A neutral or slightly alkaline reaction inside the pit, which can be obtained by mixing some ground limestone with the fermenting material.

(f) Presence of proper minerals It has been found that phosphates play an important part in bacterial activity

If some urine soaked earth mixed with dung is spread in a thin layer over alternating thick layers of the raw material, it will prove useful in retaining the fermentation products

Green Manuring.—The economics of the practice of green manuring were dealt with in an experiment conducted at Gurdaspur by taking into consideration the residual effects and it was found to be an economic proposition The results then obtained were submitted to the first meeting of the Board of Agriculture, held in February 1935 Since then a number of experiments have been carried out and it is now well established that green manuring is one of the best and cheapest methods of maintaining or increasing soil fertility, chiefly in tracts where sufficient irrigation water is available or where the monsoon starts early It has been found at Rawalpindi that under the conditions obtaining there Arhar does very well as a green manure crop, for it can germinate when it is still fairly cold, and thus provide a sufficient amount of organic matter which can be ploughed in early in the season and can thus disintegrate thoroughly during the ensuing monsoon period The choice of the best crop for green manuring will vary with the local condition and in the Punjab, Guara, San hemp, Arhar, Dhauncha are among the most important ones which, depending upon these are employed for this purpose. The question of winter green manuring deserves special attention. At Lyallpur, Senji used as a green manure for cotton gave a significant increase in yield.

Artificials.—The use of different artificial manures as a regular practice in farming in the Punjab cannot always be recommended The experiments conducted so far show that the application of nitrogenous manures in amounts less than 20 lbs. nitrogen per acre to wheat and cotton failed to increase the yields significantly. The Punjab soils do not seem to respond to the application of potassic fertilizers although a definite response to superphosphate has been noted at Rawalpindi In view of our results obtained with artificials, it seems justifiable to start, wherever possible, experiments on factorial designs in our field trials embodying a study of all combinations of two or more factors and so arrange that the number of treatments to be tested is not so large as to make it impossible to eliminate soil fertility differences adequately in which case confounding should be resorted to This will give the basal idea of the responses to different treatments and their combinations and we could then layout our trials with specified objects in view, *e.g.*, the best $N—P_2O_5$ ratio, time of application of different fertilizer combinations, etc., etc.

APPENDIX II-G.

A short note on the manurial experiments in the Punjab.

(Dr. P. E. LANDER, I.A.S., *Agricultural Chemist to Government, Punjab, Lyallpur.*)

Manuring of crops for increased yields has been an important line of investigation to which the Punjab Department of Agriculture has devoted a considerable amount of attention It is well established that the application of F. Y. M. to the soil is very useful. Since, however, this manure is not available in quantities required for efficient crop production, it is essential that its shortage must be made good by the use of other material rich in necessary plant nutrients. For maintaining the requisite amount of organic matter in the soil the use of compost manures and of leguminous crops as green manure have been studied as a complete or partial substitute for F. Y. M. The effect of different artificials—nitrogenous phosphatic and potassic—has also been tried separately as well as in conjunction with the different types of organic manures. These trials were designed to yield information which could be of practical use to the farmer. The experiments are in progress both on barani and canal irrigated soils at a number of different Departmental Agricultural Stations A considerable amount of data regarding the relative value of different types of manures has been collected during these years The main conclusions arrived at are presented in this note.

1. *Effect of F. Y. M., San Hemp compost at Rawalpindi.*

SUMMARY OF RESULTS

Treatment.	1933-34. Wheat grain.	Percentage increase over untreated plot. 1934-35 (*Residual effects.*) Wheat grain.	*Kharif* 1935 (*residual effects*) Chari fodder	1936-37 (*Residual effects*) Wheat grain.	Remarks.
1. 5 tons F. Y. M. per acre . . .	The crop was destroyed by Chrotogonus species.	17·33	10·79	4·45	This experiment is being continued.
2. 10 tons F. Y. M. per acre . . .		49·85	9 43	19·88	
3. 15 tons F. Y. M. per acre . . .		74·24	23·46	21·09	
4. San hemp compost = 1 N		15·34	17 71	3·48	
Do. = 2 N		36·54	15·04	18 38	
Do. = 3 N		51·56	41 53	24·31	

From the above it will be seen that the effect of both the organic manures is definite and in the case of the heavy doses, it is significant even after harvesting three crops. As a matter of practical importance it can be safely recommended that the application of F. Y. M. or compost manures in sufficient quantities ensures a sufficiency of organic matter and as judged from actual crop yields maintains soil fertility at a fairly high level of crop production. Compost manures prepared by decomposing green leguminous crops such as San hemp and Arhar, etc, in pits have also been tried at Rawalpindi and Gurdaspur. Owing to a shorter duration and limited number of trials it is not safe to form any definite conclusions. The indications, however, are that compost manures are inferior to both F. Y. M. and green manure. It may be mentioned in this connection that the Punjab soils in the plains require a continuous supply of organic matter and that every possible effort should be made

APPENDIX II-I.

Note on green manuring on the Deccan Canals area of the Bombay Presidency.

(V. V GADGIL, *Deputy Director of Agriculture, S C D., Poona*)

I INTRODUCTION.

With the increase in rate per cart load of Farmyard manure upto Rs 3 as a result of great demand for the stuff on account of intensive farming on the Deccan Canals manuring of the irrigated crops with coarse organic matter became a great problem and again the meagre number of cattle per holding limited to a great extent the supply of sufficient Farmyard manure required for irrigation farming The solution of these difficulties could be found, in recommending sann green manuring as the best and most economic source for the supply of organic matter to the soil to maintain its texture and structure and to conserve its fertility even such a heavy and intensive farming as is generally involved in cropping the land under a canal irrigation A couple of years after this recommendation which was done by actual practical demonstrations in the cultivators' fields the practice of Sann green manuring is very rapidly becoming more and more popular in the canal area as will be seen from the quantity of seed of sann which could be distributed on Deccan Canals by the Department for the purpose of sann green manuring in addition to the seed preserved by the irrigators themselves from their sann crop of the previous years :—

Year.	Quantities of sann distributed by the Department Lbs.
1928-29	1,000
1929-30	19,000
1930-31	20,000
1931-32	1,32,000
1932-33	84,870
1933-34	75,000
1934-35	50,000
1935-36	88,300
1936-37	31,260

This work is now entrusted to Agricultural requisits Societies on all the canals, and several local merchants are supplying the sann seed directly to the cultivators.

II. ADVANTAGES.

Sann green manure is recommended as it can most efficiently achieve the following objects :—

(1) It is the best and most economic substitute for farmyard manure for the supply of humus to the soil.

(2) Sann crop prevents weeds and eradicates the existing deep rooted weeds like *Larela* and *Harali* by checking their growth

(3) The sann crop brings plant food from the deeper layers of the soil to its upper layers so that it may be used up by the crops

APPENDIX II-H.

(NOTE BY RAO SAHIB K. I. THADANI, *Director of Agriculture, Sind.*)

Sind is a typical arid country with scanty rainfall—the river Indus with a Barrage at Sukkur and a net work of perennial canals supplies the irrigation water for the cultivation of crops. The soils are poor in organic matter and nitrogen content. In the past, *i.e.*, before the advent of the perennial canals, there were long fallows as the intensity of cultivation was small and thus the fertility of the land could be well maintained.

Now under the present system of perennial canals, the intensity of cultivation has considerably increased—the old fallows are no more possible. The problem of maintenance of soil fertility has assumed great importance.

1. *Farmyard manure and compost.*—The quantity of farmyard manure produced is too small and insufficient for the maintenance of soil fertility. At the same time, the method of conserving farmyard manure is wasteful. The Agricultural Department in Sind is advocating the practice of maintaining minimum number of live-stock consistent with crop growing and at the same time lays great stress on conservation of crop residues and waste organic materials and converting them into useful organic manures, *e.g.*, compost. The Indore method as described by Howard and Wad has not been found to be suitable for Sind conditions. This has been greatly modified and a new improved method of preparing compost in heaps above ground instead of in pits has been found out and has proved to be simple and cheap and at the same time a high grade manure is produced by this method. This has been described in Leaflet No. 52 of the Agricultural Department in Sind. Compost made according to this method is ready for carting to the field at the end of 3 months. Fifty cartloads of compost per pair of cattle maintained can be made each year and very little additional labour other than is usually employed in care of cattle and cleaning sheds and standings, is necessary.

2. *Green manuring.*—In order to encourage cultivators in the district to take steps to maintain the fertility of their land, Government of Sind have granted important concessions in connection with the cultivation of green manure crops which are permitted under certain conditions to be cultivated free of assessment. So far very little advantage of these concessions has been taken in the districts. The system of land tenure in Sind, *i.e.*, zamindar and *hari* (tenant), the rapid extension of cotton cultivation and the inherent fertility of Sind soils are all factors which militate against the extension of green manuring in the Province. The following investigations are being carried out :

(*a*) The suitability of sann-hemp and *guar* (cluster bean) and other crops as green manures.

(*b*) Comparative value of kharif and rabi green manure crops.

(*c*) Green manuring as compared to the effects of a leguminous crop grown and harvested.

(*d*) Relative merits of application of identical quantities of fertility ingredients to the soil in organic and inorganic forms.

The practice of growing *guar* (cluster bean) in alternate rows with cotton for green manuring purpose is also being tested on a large scale and has given excellent results in many places.

3. *Artificial manures.*—In Sind a minimum basic dose of a bulky organic manure is considered necessary in all experiments with artificial manures owing to the lack of organic matter in the soil and that saline nature of the soil. A top dressing of sulphate of ammonia to the cotton crop at the time of flowering has been found to be beneficial. The wheat crop has also been found to respond favourably to the application of sulphate of ammonia on a piece of land which had been continuously cropped with jowar and wheat to bring down the fertility of the soil so as to exhaust it for purpose of such manurial experiment.

(4) *Season and time of sowing*.—The season for sowing sann is the Kharif one It is not tried in the *Rabi* season Generally it is sown as a monsoon crop after the 15th of June i.e., a week after the break of the monsoon. The vigour and the growth of the crop are just normal when sown after 15th June But it is observed that sowing it in the last part of the hot weather i.e, between 15th May to 5th June is best as the vigour of growth of such a crop is excellent and consequently more green weight is obtained Some irrigators argue that sowing sann in April gives them still higher weight of green matter, this may be true when there are no heavy hot winds, or else it may be scorched by heat in the very young stage of the crop It is noticed that sann crop sown in April is liable to attack by insects (small green catterpillars) and on account of damage to sann crop by these insects sann crops of some irrigators have failed So under the climate of Bombay-Deccan 15th May to 5th June is the best time for sowing of sann as is found to be the experience of the last several years

(5) *Seed rate and sowing*.—The seed rate of sann varies from 60 to 80 lbs per acre according to the kind of soil heavier types of soils requiring more seed rate as the population of the plants from more seed rate per acre gets sufficient plant food from such soils; while on lighter types it is better to sow 60 lbs of seed only Sowing is done cross-wise by the local seed drill having coulters 10" to 11" apart Where the soil is infested with more weeds a thicker seed rate is advocated so that the thick crop does not allow the weeds to grow and naturally they are suppressed

Sowing in hot weather is done by first flooding the land then waiting till wapasa i.e., till the land is assessible for sowing operation

(6) *Irrigation*.—If the crop is sown on 25th May by flooding the land on 22nd May the 1st irrigation will have to be given on 31st May Then comes the monsoon and only during very long breaks of rains it requires 3 to 5 additional waterings In the monsoon season If the rainfall is sufficient and evenly distributed it requires only one watering or no watering at all During the year of scanty rainfall one watering may be found necessary after burying in the crop to help its decomposition

(7) *Time of cutting and burying*.—The crop just flowers 2½ to 3 months after sowing If the crop is sown on 25th May it will be ready for cutting and burying into the soil in 3rd week of August.

IV Weight of Green Matter per Acre

The weight of green matter per acre varies on different kinds of soils but for medium soils the average weight of green matter varies from 20,000 to 25,000 lbs. It will be seen that on Nira Bank Right Canal where soil is devoid of previous organic matter the weight of green matter has not exceeded 17,800 lbs while on Nira Left Bank Canal due to continuous manuring under irrigation for the last 40 years the soil has given the green weight of sann up to 69,800 lbs This weight of green matter of sann crop per acre depends on several factors as explained above

V Causes of Failure of Sann Crop

(a) *Soil*.—The factors which lead to failure of sann crop as far as soil is concerned are water-logging alkaline salts, heavy stiff soils of bad texture and very shallow light soils devoid of organic matter, and with less water holding capacity

(b) *Climate*.—Under this heading very hot winds at the young stage of the crop, cold weather and cultivation out of season are the factors which are unfavourable for the sann crop During some seasons it is observed that if the sann crop is sown late i e, in July or even in the last week of June it gets ready for cutting and burying into the soil by the end of September and if there are very heavy rabi rains in the middle of September the operations of cutting and burying into the soil of the sann crop are so much impeded, that some times they become impossible and the crop has to be left for production of seed the yield of which also is not more than 300 to 500 lbs per acre on account of the dropping of pods in the heavy September rains

(c) *Disease*.—The sann crop is affected with a disease called wilt which was observed on the Manjri Farm and later in the districts This prevents growth of the crop but it is not prevalent to the extent of any appreciable damage. A wilt resistant strain of sann has now been evolved and it will solve this difficulty.

(4) Sann green manure increases the fertility of the soil by the supply of nitrogen in the sann plant and by nitrogen fixation from air by the root nodule bacteria.

(5) It improves the water holding capacity of light soils by flocculation of soil particles and of heavy soils by deflocculation of soil particles

(6) It greatly improves the texture and structure of soils so that they provide a good stronghold for roots of crops by allowing them to go as deep as they can.

(7) It increases the aeration of soils so that the activities of soil organisms (bacteria) such as nitrification and nitrogen fixation in the soil are accelerated which processes are quite essential for the life of a plant.

(8) It increases the power of percolation of heavy stiff soils.

III. Method of Sann Green Manuring

(a) Sann green manuring is done by first growing the crop as described below and then by burying it into the soil *immediately after it begins to flower*, by cutting the first few rows of the crop, working a plough, putting the cut plants in the furrow opened by the plough and then taking the next turn of the plough so that earth falls on the plants covering them fully. Second ploughing is found to be advantageous, a month and half after burying the sann crop as it helps towards decomposition by aeration and by further mixing of the half decomposed portions of the plants with soil

(b) *Cultivation of sann crop*—(1) *Soil*—The sann crop does well in light, medium black and heavy black soils of the Deccan. The variation in the green weight of sann crop per acre is from 7,360 lbs to 17,424 lbs. on light soils, from 11,040 lbs. to 69,800 lbs. on medium black soils, the latter weight having been obtained on the good residual manure after sugarcane crop and from 23,760 lbs to 35,420 lbs on deep black soils on Nira Left Bank Canal

Here the substratum for light and medium black soils is soft murum while that of the deep black soil is shadu. Sann crop is reported to have failed on very light shallow soils and very heavy stiff soils on account of poor growth. Still however if whatever green weight is obtained on such soils, is buried in it is hoped that sann green manuring on such soils also will improve their physical condition

On water-logged and salt affected soils sann does not germinate as is found to be the experience of the salt land Farm at Baramati. Here germination of sann is taken to be a test to see whether the land is reclaimed or not after washing off the salts by flooding, percolation and open and closed drainage

On slightly salt affected soil of the Loni School sann crop has given 22,000 lbs green weight which is an average figure for three years

So it will be seen that sann does well on a wide range of soils

(2) *Climate*—(a) *Rainfall*—Sann grows satisfactorily well under irrigation in the Deccan Canal Tract which has got an average rainfall of 20 to 25 inches. It does well under less than the above rainfall also provided the rainfall is more evenly distributed so that the climate is humid which is preferred by the crop.

(b) *Temperature*—Temperature does not appear to be an important factor in the cultivation of sann because it is found to be doing well in regions with wide range in temperatures

(c) *Hot winds*.—These also do not seem to affect the sann crop except perhaps the one sown in April the growth of which may be affected to some extent in its younger stage when it may not be in a position to stand very hot winds.

(3) *Preparatory tillage*—(a) *Ploughing*.—If the previous crop is cotton after cane or even after any deep rooted crop the land will have to be ploughed up once at least

(b) *Harrowing*.—If, however, the previous crop is *Jowar* or wheat two harrowings only will serve the purpose of preparatory tillage. After ploughing where it is necessary two harrowings will have to be given to the land to bring the soil in good tilth for the sowing of sann.

These profits are taken on the safer side Adding Rs. 20 or 25 to Rs 43 the cost of sann green manuring the sum arrived at is less than Rs 75, the cost of 30 cart loads of Farmyard manure and hence their argument is not correct. As there are very great advantages from sann green manuring in addition to its economic cost this kind of argument is not in any way forcible in favour of Farmyard manure as against Sann green manuring which is being advocated with all means possible.

VII EFFECT OF SANN GREEN MANURING ON THE YIELDS OF SUGARCANE CROP AS COMPARED TO THAT OF FARMYARD MANURE.

The following statement indicates the results in favour of sann green manuring :—

Year.	Sann green manure 24,000 lbs weight cost Rs. 50.	30 cart loads of Farmyard Manure cost Rs 90.
1029-30 . . .	9,481 lbs. Gul. . . .	9,216 lbs. Gul.
1030-31 . . .	10,030 lbs Gul.	9,846 lbs. Gul.

Moreover in the crop to which Farmyard manure was added the weeding expenses were Rs 15 per acre as against Rs 6 in the case of the crop taken after sann green manuring because there were very few weeds in the green manured plots while weeds thrived more in the plots of Farmyard manure

So also in the case of *Jowar* and Wheat crops the yields are increased considerably as shown below :—

Year.	Crop after sann green manuring.	No. sann reen manuring	Remarks.
	Lbs. Grain	Lbs. Grain.	
1029-30 . .	082 „ .	688 „	Wheat
1030-31 . .	844 „	506 „ . . .	„
1028-29 . .	2,352 „ . . .	1,702 „ . . .	Jowar (Soil very good)
1029-30 .	840 „ .	316 „	„ „
1030-31 . .	1,307 „	734 „	Jowar

Year.	Sann green manuring.	Without green manuring.	Remarks.
	Lbs	Lbs	
Yield of Wheat			
1931-32 . . .	528	224	Dry.
1932-33	1,436	827	Irrigated.
1033-34 . .	1,335	790	Do.
1034-35 . .	1,140	850	Do.
Yield of Jowar after sann green manuring.			
1934-35	1,400	1,015	Irrigated.

VI. ECONOMICS OF SANN GREEN MANURING AS COMPARED WITH FARMYARD MANURE.

The unit value of nitrogen from sann green manuring can be calculated by working out the figures of cost required for it which are detailed below :—

	Rs.	A.	P.	
(1) One ploughing.	6	0	0	
(2) Two Harrowings	2	4	0	
(3) Seed 60 to 80 lbs	3	8	0	at 20 lbs. per rupee.
(4) Sowing	1	4	0	
(5) Irrigation labour	0	8	0	
(6) Irrigation Cess	3	0	0	
(7) Cutting sann crop	2	8	0	
(8) Ploughing in sann	7	0	0	
Total	26	0	0	
(9) Rent of sugarcane land	15	0	0	
(10) Interest on Rs. 26 at 9 per cent	2	0	0	
Grand total	43	0	0	

Yield	=20,000 to 25,000 lbs. of green matter which contains 45 per cent. Nitrogen.
	=101 2 lbs. nitrogen from 22,500 lbs. for Rs 43.
So the unit value of nitrogen from sann green manuring is	=Re. 0-6-9
One cart load of Farm yard manure contains	=600 lbs. of matter containing 5 per cent. N.
Value of one cart load of Farmyard manure	=Rs 2-8-0
So the unit value of nitrogen from Farmyard manure	=Re 0-10-0

Thus it will be seen that *sann green* manuring is cheaper than Farmyard manure and has the additional advantages explained above

Some irrigators argue that *sann green* manuring they lose one *Kharif* crop such as early variety of groundnut or Nilwa *Jowar* for fodder but the following statements clearly show that even though the *Kharif* crop is lost still sann green manuring is more profitable than applying Farmyard manure :—

Crop.	Cost of Cultivation.	Value of yield.	Net profit.
	Rs.		Rs
Nilwa	40	Rs. 60 for 6,000 lbs. dry fodder at 100 lbs. per rupee.	20
Ground-nut	50	Rs. 75 for 2½ Khandis at Rs. 30 per Khandi.	25

APPENDIX II-J.

Green manuring for the Block cotton soils of the Surat tract, Bombay Presidency.

(B. S PATEL, N.D.D., N.D.A., I.A.S., *Livestock Expert to the Government of Bombay.*)

The cotton land of Surat is a typical, heavy black cotton soil of Gujarat, Bombay Presidency. Not only the soil is heavy but the rainfall is heavy and continuous in June-July and even in August with few very short breaks. Under these conditions the cotton crop makes very little progress in growth up to the end of August or even September. Besides heavy and continuous rains at the early stage of seedling kills the plant and resowing is necessary all over the tract in some years. The soil being inaccessible, weeding and interculturing becomes impossible and the growth of weeds affects the cotton growth adversely at the start and sometimes permanently and yield of crop keeps low.

From time to time the Agricultural Department has tried various ways to get better yield of crop in Surat tract with some success. The last successful effort was made by Dr Mann and Rao Bahadur Bhimbhai by growing cotton on 14" high ridges made by repeated use of Disc harrow by interculturing between the two rows of cotton. This method was designed to prevent waterlogging at the roots of cotton seedling and gave better stand and good start to the crop. The yield of the crop varied according to the degree of waterlogging that the season caused. In years of lighter rainfall and less waterlogging condition for the seedling the increase in yield was less. The average results of the experiment carried out for seven years show that cotton on high ridges with shallow tillage gave an increase of 6.4 per cent. in yield over cotton sown on flat with similar tillage, whilst deep tillage combined with high ridges gave an increase of 13 per cent in yield. *Jowar* results were slightly better. This shows the high ridges did not give great increase in yield over long period.

With a view to get higher yields another experiment was going on at the same time and the average results of the application of 10 tons of Farmyard manure per acre to cotton crop sown on high ridges with deep tillage over seven years showed an increase of 31 per cent in the yield of seed cotton over no manure to cotton on ridges with deep intertillage.

These experiments show that prevention of waterlogging at the roots of cotton seedlings may give 6 per cent increase in yield of seed cotton and the application of 10 tons of Farmyard manure every alternate years may give an increase in yield of seed cotton by 25 per cent (31—6) over long period. This is a good increase in yield but it is not possible to find sufficient Farm Yard Manure for the total cultivated area even if it would pay to apply such a heavy dose.

The close practical acquaintance with the soil and crop conditions in Surat tract and the scientific scrutiny of the experiments shown above show that if we are to tackle the question of higher yield of crops in Surat tract the physical condition of soil should be so improved that it may provide a healthier home for cotton seedlings and at the same time maintain fairly good soil condition and aeration necessary for the good growth of plant. Such a method should form a part of the farming practice of the tract, and should be within the means of the cultivator.

Two things suggested to me—Firstly to find a leguminous green manure plant that will grow well and quickly in heavy waterlogged soil and *Dhaincha* or Ikkad (*Sesbania aculeata*) was selected. Secondly to find a practical way of growing it as green manure crop in the system of crop rotations locally followed without losing a crop. So it was decided to grow it in two ways: (1) by growing it in strips between two rows of cotton crop and (2) by growing it before a crop of monsoon jowar. In Surat District the cultivator grows a row of Saun or few rows of *Udid* (*Phaseolus radiatus*) between two rows of cotton sown 4 feet apart and these are used as green manure crops after couple of months. I therefore decided to grow Dhaincha between two rows of cotton.

In Surat tract cotton is sown soon after rain but *jowar* is sown a month later. So it was decided to work out a method of growing *Dhaincha* before jowar even by sowing *jowar* a month later. Preliminary experiments were started in 1931-32

VIII. Further Investigation Necessary into the Following Points.

(1) *Applying compost of Sann Crop instead of burying it in situ.*—The Authorities at the Institute of Plant Industry, Indore, maintain that preparing compost of sann crop and then applying it to the soil give better results than burying it in situ explaining that if the sann crop is buried in situ the energies of the soil are wasted in decomposing the sann crop which happens in winter when the soil has got to be preparing nitrates; and this affects the nitrate formation in the soil whereas if the compost of sann is applied, the soil gets rest and natural process of nitrification is not hampered.

This matter needs to be investigated by devising some systematic experiments on the Padegaon Sugarcane Research Station.

(2) *Applying Farmyard Manure to the Sann Crop.*—It is the experience of a few irrigators on Godaveri Canals that applying 10 cart loads of Farmyard manure doubles the green weight by 100 per cent. It is necessary to find out how far this is correct and economical.

(3) *Simultaneous Sann Green Manuring.*—This was experimented upon on the Manjri Farm but quite decisive results are not available. The matter may again be taken up for investigation.

(4) *Double Sann Green Manuring.*—Irrigators having heavy soils found out that sowing sann in April burying it in July, resowing in August and burying it in October for next planting of cane considerably improves the physical condition of their soils and give still better results than single sann green manuring. This may be investigated *from economic point of view*. It will have to be seen whether in presence of too much organic coarse material in the soil the existing nitrates are depleted owing to their having been used up by the organisms while decomposing it and whether the better results as claimed by the irrigators are possible only on account of the improvement of the physical condition of their soils.

IX. Other Green Manuring Crops.

As stated above, the Sann does not thrive in the water logged areas hence two crops viz., *Dhaincha* and *Shevri* (*Sesbania Egyptica*) were tried in the water logged areas and they have proved very successful. The use of Shevri however is made for cattle food and it is also less hardy. *Dhaincha* has proved very efficient as a green manure and has yielded from 40,000 to 50,000 lbs. of green matter per acre. The cultivators on the Nira Left Bank Canal are now utilising Dhaincha for green manure in the water logged areas.

One more crop which has proved very useful for green manure both as the dry and irrigated crop is Ran-Matki, *Phaseolus Trilobus*. This crop produces from 15,000 to 17,000 lbs. of green matter per acre and is easily rotten within a month. This manure is specially suitable for *Rabi Jowar* and wheat and its effect is very marked. The land intended for *Rabi* crops is generally kept fallow and if Ran-Matki is grown on such lands, it will serve very useful purpose in increasing the yield as well as by supplying fodder to cattle in times of emergency. The experiments with Ran-Matki were conducted at the Kopargaon Farm and results of the last three years are as follows:—

Year.	Yield of Jowar per acre.		Check		Remarks.
	Green manured Grain.	Fodder.	Grain.	Fodder.	
	Lbs.	Lbs.	Lbs.	Lbs.	
1934-35 . .	1,536	3,276	699	1,568	
1935-36 . .	1,355	4,539	871	2,203	
1936-37 . .	952	1,458	844	1,172	Season not favourable.

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This experiment was started in 1934-35 the object being to add organic matter to the soil and to get increased yield without losing the season There are 4 treatments arranged in a Latin Square as under :—

(1) *Jowar*—No Manure—Control

(2) *Jowar* manured with Farmyard Manure at 5 cart loads per acre

(3) *Jowar* after Dhaincha green manuring.

(4) *Jowar* after Dhaincha green manuring and Farmyard Manure at 5 cart-loads per acre

Dhaincha is buried after about a month's growth giving about 25,000 lbs green stuff per acre

The average results of three years (1934-35 to 1936-37) are as under :—

Treatments.	Average yield of jowar grain per acre in lbs	Percentage increase or decrease over control.
1. Jowar—No Manure—Control . .	1,236·34	..
2 Jowar *plus* Farmyard Manure .	1,268·95	2·62
3 Jowar *plus* Dhaincha . .	1,220·22	—1·30
4 Jowar *plus* Dhaincha *plus* Farmyard Manure	1,176·07	—5·62

Dhaincha alone and with Farmyard Manure was significant in the first year over control and Farmyard Manure.

In the last two years the yield results were not favourable owing to deficiency of late rains In 1935-36 in the green manure plots the season being too late for *Kharif jowar*, Semi Rabi Nialo *jowar* had to be sown. Average weight of green manuring stuff buried per acre for three years was 27,692 lbs, *i e.*, 111 lbs. N for Dhaincha+Farmyard Manure and 23,789 lbs green stuff *i e*, 95 lbs No. for Dhaincha alone

The average results of the residual effects of green manuring practised before *jowar* in 1934-35 and 1935-36 on the next crop of cotton grown in 1935-35 and 1936 37 are given below —

Treatments	Average yield of seed cotton per acre in lbs.	Increase in percentage over control
1 No manure *(control)* . . .	535 03	..
2. Farmyard Manure to previous jowar . .	540·06	0·94
3. Dhaincha Green Manure to jowar . .	665·53	24·39
4. Dhaincha Green Manure and Farmyard Manure to jowar . . .	755·69	41·24

The residual effects on the next year's cotton crop for the two seasons are remarkable, giving 24 39 per cent and 41-24 per cent. more yield of seed cotton over control, for Dhaincha alone and with Farmyard Manure respectively. Dhaincha alone and with Farmyard Manure was significant over control and Farm Yard Manure in both the years

3 *Rotational and Green Manuring Experiments*—

Cotton dibbled 5′ x 2″

Jowar dibbled 2½′ x 1′.

Gross area of each plot = 20′ x 112′.

on the Surat Farm to work out a practical method of growing *Dhaincha* as green manure crop in strips between two rows of cotton and before cotton and jowar soon after rain. These preliminary trials showed that we can successfully grow *Dhaincha* in strips between two rows of cotton though the yield of green matter is not very heavy, expecting that repeated green manuring in every successive cotton crop would help to build up the soil fertility and the crop yield would increase

As regards growing green manure crop before cotton or jowar the preliminary experiments showed that cotton if sown late in the season after green manuring, yielded much less than the normal crop whilst in case of jowar if sown late, the yield was not materially reduced, so it was decided to grow *Dhaincha* before jowar cotton being more than 8 months' crop and jowar being six months' crop.

Regular experiments were laid out in 1934-35 as described below :—

1. *Cotton Green Manuring Experiment.*—

Cotton drilled 6′ × 1½′.

Gross area of each plot = 24′ × 152′.

Net area after deducting = 18′ × 144′

This experiment was started in 1934-35 with a view to add organic matter to the soil and to get increased yield of cotton without losing the season There are four treatments, replicated as many times and arranged in a Latin Square as under :—

(1) Cotton—No Manure—(Control) drilled 6′ apart.

(2) Cotton drilled 6′ apart with Dhaincha in the middle 1′ strip.

(3) Cotton manured with Farmyard manure at 5 cart-loads *per* acre

(4) Cotton manured with Farmyard manure at 6 cart-loads and with Dhaincha, in the middle 1′ strip.

Dhaincha is buried after about a month's growth giving about 7,000 lbs green stuff per acre. *Dhaincha* was broadcasted in the middle strip when cotton was sown.

The average results of the three years are as under :—

Treatments.	Yield of seed cotton per acre in lbs.	Percentage increase or decrease over control.
1. Cotton—No Manure—Control . .	532 7	
2. Cotton *plus* Dhaincha . .	623 79	17·08
3. Cotton *plus* Farmyard Manure .	571 9	7·35
4. Cotton *plus* Farmyard Manure *plus* Dhaincha	630 85	18 42

Farmyard Manure *plus* Dhaincha was significant over control and Farmyard Manure in the last two years Dhaincha alone was significant over control and Farmyard Manure in 1935 36.

Average weight of green stuff of Dhaincha with and without Farmyard Manure was 7,157 lbs. and 6,005 lbs. respectively.

Next *jowar* crop gave 8 60 per cent and 12 71 per cent more yield over control, after Dhaincha alone and with Farmyard Manure respectively. Dhaincha *plus* Farmyard Manure is significant over control, Farmyard Manure and General Mean

2. *Jowar Green Manuring Experiment.*—

Jowar drilled 3′ × 1′.

Gross area of each plot = 24′ × 152′.

Net area after deducting ring = 18′ × 144′.

In case of green manure plot, drilling is not possible and hence *jowar* has to be sown with a plough.

This experiment was started in 1934-35 the object being to add organic matter to the soil and to get increased yield without losing the season There are 4 treatments arranged in a Latin Square as under:—

(1) *Jowar*—No Manure—Control

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The residual effects on the next year's cotton crop for the two seasons are remarkable, giving 24 39 per cent and 41 24 per cent. more yield of seed cotton over control, for Dhaincha alone and with Farmyard Manure respectively Dhaincha alone and with Farmyard Manure was significant over control and Farm Yard Manure in both the years

3 *Rotational and Green Manuring Experiments*—

Cotton dibbled 5′×2″.

Jowar dibbled 2½′×1″.

Gross area of each plot=20′×112′.

This experiment is carried out since 1934-35 There are 8 treatments randomised into 5 replications as under :—

A. Green Manuring—fallow.

B. Cotton after green manuring

C. *Jowar* after cotton.

D. Cotton after *jowar.*

E. *Jowar* after cotton

F. Cotton after *jowar.*

G. Cotton after *jowar.* } No green manuring at all—control.

H. *Jowar* after cotton }

Thus in a cycle of 6 years, each plot except those having the treatment (G) and (H) *i.e.*, controls, will receive green manure once in 6 years The object is to compare the yields of cotton and *jowar* with no manure in the rotation

Dhaincha is buried in the soil when about 2 months old, the green stuff buried per acre being about 35,000 lbs

The average yield results of two years are as under —

Treatments.	Average yield of seed cotton per acre in lbs.	Percentage increase or decrease over control.
1. Cotton after jowar (Control) (G)	534·91	
2. *Cotton after green manuring (B)*	*1,180 93*	*122·45*
3. Cotton after jowar (D)	563·52	5 33
4. Cotton after jowar (F)	542 91	1 5

Green manuring is significant over all including general mean Average weight of green manure stuff buried per acre in two years was 34 069 lbs , *i e*, 135 lbs. N

Residual effects on the next jowar crop (C) are seen in increased yield of *jowar* grain by 4 2 per cent. and fodder by 84·24 per cent over control for 1936-37 Owing to deficient rainfall, increase of grain yield is not proportionate to that of fodde which is significant over control and general mean

The green manuring experiments show that the strip system of partial green manuring even has given as much as 17 per cent increase in the yield of seed cotton. The entire green manuring before *Jowar* has given an increase of 24 per cent. to 41 per cent. in the yield of seed cotton and the green manuring fallow has increased the yield of next cotton by 122 per cent which perhaps shows the maximum increase that may be expected by building up fertility of land by repeated green manuring in course of time and by supplementing it with other quick acting manures. The increase obtained by 10 tons Farmyard Manure was 25 per *cent* and that has been equalled by one green manuring in the rotation before jowar. The yield of *jowar* has been slightly reduced over three years but considering this small loss the gain is greater and is expected to be still greater when the soil fertility is built up by repeated green manuring

The practical observation has shown that the physical condition of soil is greatly improved. The green matter does not rot thoroughly before jowar and in cotton but under the peculiar heavy conditions of the Surat soil this is an advantage rather than a drawback.

I may mention that a catterpillar pest at times becomes serious on Dhaincha as it probably attracts the pest first by its early growth but this pest has been easily and successfully controlled by dusting with Paris green at a cost of Rs. 2 per acre Besides this, this practice of green manuring has been of great help in controlling weeds.

APPENDIX II, K.

Review of the work on green manuring carried out in the Central Provinces.

(RAO SAHIB D. V. BAL, *Agricultural Chemist to Government, C. P. and Berar.*)

A great deal of attention has been paid to the problem of green-manuring in the Central Provinces by the Department of Agriculture, since the year 1910. A number of different plants such as sann-hemp (Crotalaria Juncea), *sawri* or *dainchya* (Sesbania aculeata), *tarota* (Cassia tora), wild indigo, and *Kodojira* (Vernonia cinerea) have been tried for the purposes of green manuring, and of these sann-hemp and *tarota* have been more commonly used than the others (2).

In the case of wheat, *sann* was grown *in situ* and was subsequently ploughed in the soil, some time before the crop was sown. In the case of paddy, attention was paid to the possibility of growing *sann in situ* and its subsequent inversion at the time of transplantation, or the provision of green material grown on open fields adjoining the rice *bandhis*.

Results of field experiments have shown the following:—

(*a*) *Green-manuring for paddy crop.*—Results obtained conclusively show that green manuring is of immense value to the paddy crop and its effects are considerably intensified when used in conjunction with phosphatic fertilizers like bonemeal or superphosphate, the fertilizer being applied at the time of sowing the green-manuring crop.

Not only does an application of *sann* in conjunction with phosphatic fertilizers give a significantly higher yield than that given by an application of *sann* alone, but the former treatment increases the percentage of P_2O_5 in paddy seed while the latter reduces the same. It is important, therefore, both from the point of obtaining high yields and also from the point of nutrition, that whenever green manure is applied to the paddy fields an adequate quantity of phosphatic fertilizer should also be applied (6).

If the green manure is applied either one or preferably two weeks before the date of transplantation of the rice seedlings, the yield obtained is considerably higher than that obtained when the green manure is incorporated with the soil at the time of transplantation (8).

As the rice plant prefers a slightly acidic or neutral medium to an alkaline one for its growth, applications of green manure in conjunction with sulphur only or a mixture of sulphur and super have been found to be useful on heavy soils brought under rice for the first time, as these reduce the pH value of the soil, and thus help to quicken the establishment of paddy crop on newly bunded rice fields which were formerly open heavy soils growing rabi (winter) crop (4).

Experiments have shown that for a satisfactory growth of *sann* in rice tracts one of the following three conditions is essential:—

(1) Well drained fields, (2) early monsoon and (3) irrigation facilities.

In regard to the three conditions mentioned above, the first is rare, the second is unusual and the third is practically speaking absent. In the Central Provinces we are thus compelled to consider only the alternative of bringing in the green crop from another area or from waste land. Grasses and other vegetation growing on the *bunds* may also be utilized for this purpose thus securing a two-fold advantage of enriching the land with organic matter and of clean cultivation. In this connection the possibility of growing perennial or annual quick growing legumes on the *bunds* of rice fields, borders of *kharif* and *rabi* fields and on available waste areas, with a view to supplying green manure and also fuel to some extent deserves a very careful consideration (7).

(*b*) *Green manuring in the case of kharif crops other than rice.*—It is not at all a common practice to use a green manuring crop followed by a crop like gram in a *kharif* field, in a year previous to that in which the main crop like cotton is to be sown. This system may, however, be found very useful in improving poor fields, provided rainfall conditions are satisfactory, as according to this system a cultivator can expect to get at least some return from his field, instead of nothing, if he were to follow the practice of green manuring only in order to improve the land which may be very poor.

This experiment is carried out since 1934-35. There are 8 treatments randomised into 5 replications as under :—

A. Green Manuring—fallow
B. Cotton after green manuring
C. *Jowar* after cotton
D. Cotton after *jowar*.
E. *Jowar* after cotton
F. Cotton after *jowar*.
G. Cotton after *jowar*. } No green manuring at all—control
H. *Jowar* after cotton }

Thus in a cycle of 6 years, each plot except those having the treatment (G) and (H) i.e., controls, will receive green manure once in 6 years. The object is to compare the yields of cotton and *jowar* with no manure in the rotation.

Dhaincha is buried in the soil when about 2 months old, the green stuff buried per acre being about 35,000 lbs.

The average yield results of two years are as under :—

Treatments	Average yield of seed cotton *per acre* in lbs.	Percentage increase or decrease over control.
1. Cotton after jowar (Control) (G)	534·91	
2. Cotton after green manuring (B)	1,189·03	122·45
3. Cotton after jowar (D)	563·52	5·35
4. Cotton after jowar (F)	542·91	1·5

Green manuring is significant over all including general mean. Average weight of green manure stuff buried per acre in two years was 34,069 lbs., i.e., 135 lbs. N.

Residual effects on the next jowar crop (C) are seen in increased yield of *jowar* grain by 4·2 per cent. and fodder by 84·24 per cent. over control for 1936-37. Owing to deficient rainfall, increase of grain yield is not proportionate to that of fodder *which is significant over control* and general mean.

The green manuring experiments show that the strip system of partial green manuring even has given as much as 17 per cent. increase in the yield of seed *cotton*. The entire green manuring before *Jowar* has given an increase of 24 per cent. to 41 per cent. in the yield of seed cotton and the green manuring fallow has *increased the yield of next cotton by 122 per cent. which perhaps shows* the maximum increase that may be expected by building up fertility of land by repeated green manuring in course of time and by supplementing it with *other quick* acting manures. The increase obtained by 10 tons Farmyard Manure was 25 per cent. and that has been equalled by one green manuring in the rotation before jowar. The yield of *jowar* has been slightly reduced over three years but considering this small loss the gain is greater and is expected to be still greater when *the soil fertility is built up by repeated green manuring.*

The practical observation has shown that the physical condition of soil is greatly improved. The green matter does not rot thoroughly before jowar and in *cotton* but under the peculiar heavy conditions of the Surat soil this is an advantage rather than a drawback.

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APPENDIX II, L.

Crop rotation and soil fertility.

(T. J. MIRCHANDANI, *Agricultural Chemist, Bihar*)

A good deal of qualitative and some quantitative data is available in the province, regarding the suitability of certain crop rotations for different types of land and varying climatic conditions. In deciding upon the suitability of a rotation, several points have to be considered The principal amongst them are: (1) Proper distribution of area under various crops, (2) Demand for the major crop or crops and the importance of the individual crops in the rotation, (3) Water requirements of crops and how they are met, (4) Effect on soil fertility It is the last one that would be specifically referred to in this note as research on this problem has not yielded sufficient quantitative data An injudicious crop rotation might easily ruin the soil, resulting in the deterioration of yield, and it would be long, expensive process to bring up the level of fertility to normal Great care is specially necessary under Indian condition, where quick deterioration is likely to occur on account of the low level of organic matter and nitrogen in most of the soils They contain ·03-·07 per cent. nitrogen and 0 6 per cent carbon against 0 1 to 0·17 per cent nitrogen and 3 0 per cent, carbon in European and American soils. The maintenance of soil fertility by rotation or manuring or both is, therefore, one of the pressing problems in Indian agriculture

Rotation must naturally vary with the requirements of the tract In Bihar, for instance, sugarcane is our important crop and being a heavy as well as a long season (14 months) crop, it exhausts the land more than other crops do The rotation for cane lands in Bihar keeps the requirements of this crop to the forefront. The Bihar soil has a good average fertility and the main cane tract is rain-fed The department of Agriculture, in Bihar, recommends the following general rotation, with modification to suit different conditions. It is, sugarcane, monsoon crop for fodder or seed, *Rabi*, green manure and cane. In Sind, on the other hand, cotton in *Kharif* (extending into part of *Rabi*) and wheat in *rabi* are the important crops The rotation in that area would have the needs of these two crops in view; the problem is further complicated by the fact that the irrigation is controlled though assured, and in certain large areas, the soil is alkaline Both these factors play an important part in deciding upon a crop rotation *Kharif*, *Rabi*, *Rabi* is recommended, with variation in the types of crops, depending upon their sowing dates, alkali resisting or reclaiming properties in other factors Similarly, there are varied soil and climatic conditions in other parts of India Through experience and general knowledge of the local soil and crop conditions, rotations have been fixed but no intensive research has been done on (*a*) Varying the rotation by the substitution of new crops, (*b*) Role of legumes *versus* non-legumes as green manuring crops in maintaining soil fertility. (*c*) Narrowing or widening the rotation, *i.e.*, converting a three years rotation into two years one, in order to produce more of the major crop or *vice versa* The information on these points seems essential in view of the intensive farming that is being done in several provinces Instances are known when a cultivator grows on his own or leased land, a money crop, year after year, with or without manure depending upon his means, unmindful of the permanent damage he may be doing to the land There are also instances like these of the certain cane factory owners having lands of their own, who do not wish to be concerned with the production and disposal of the rotational crops but who grow cane after cane, with or without green manuring crop in between, and who spend large sums of money on manures to keep up the soil in fit condition for growing the crop they want While it is generally accepted that land can not bear strain of the Imperial Council of Agricultural Research or by a special committee and get a quantitative measure of the lowering of fertility, if any, resulting from any set of conditions It seems necessary to initiate research on this fundamental problem in land husbandry This would no doubt bring us to the definition of soil fertility For general purposes, chemical and physical examination of the soil combined with its crop raising power would supply adequate information on the fertility status of the soil.

It is suggested that the Board should obtain, by means of a questionnaire, all the available informations in the provinces The data could be sifted in the office of the Imperial Council of Agricultural Research or by a special committee and compiled so that further research could be undertaken keeping in view the knowledge already gained under varied climatic and soil conditions

Experience has also shown that when sann hemp is grown as a fibre crop, due to the leaves falling on the ground and the root residues left therein, the subsequent cotton crop gives a far better yield than obtained from a field previously cropped with either cotton or *juar*. The success of this practice will, however, largely depend upon how far sann-hemp can be grown as a remunerative fibre crop.

(c) Green-manuring for rabi (winter) crops.—Experiments on green-manuring with *rabi* crops have been confined to wheat only. In areas where there are no irrigation facilities and the annual rainfall is less than thirty-five inches, green manuring for a *rabi* crop is practically out of question. In areas with a higher rainfall which is fairly well distributed throughout the rainy season, so as to allow a good growth of the green crop, green-manuring for wheat would be successful, provided that at least twelve to sixteen inches of rain is received after inversion of the green crop in the month of August and before wheat is sown in the following winter. If irrigation is available, deficiency in rainfall can be made good, but in such cases it is necessary to apply the irrigations before the wheat crop is sown and not after, so that the green material added to the soil is properly decomposed before wheat is sown (1).

Yield of green manure obtained under different conditions.—Experiments on the growth of *sann*, *Dainchya* and cowpea on different farms have shown that, depending upon climatic conditions, the following average yields of green crop can be expected if the crop is two months old at the time of cutting :—

Name of crop.	Quantities of green-crop per acre.					
	Rice tract			Wheat and cotton tracts		
	lbs.		lbs	lbs.		lbs.
Sann	4,000	to	10,000	15,000	to	22,000
Sawri or *Daincha*	3,000	to	8,000	10,000	to	20,000
Cowpea	3,000	to	7,000	12,000	to	16,000

Studies on the decomposition of green manuring plants.—Observations on the rate of growth of sann-hemp and *Daincha* in black cotton soil show, that the latter is a comparatively slow grower in its initial stages. As the green plants advance in age, the proportion of leaf to stem decreases and the percentages of dry matter and fibre increase. Earlier the sann-hemp is used as green-manure, the more rapid is decomposition of its carbonaceous and nitrogenous constituents. Nitrogen in the leaves of sann-hemp is more easily nitrified than that in stems. The slowness of *decomposition in full-grown green sann* plants is not due to any retarding effect of the increasing proportion of stems on leaves but it appears to be due to the change in composition of the plants and such alterations which take place in the physical condition of the plant tissues owing to partial drying as a result of a large reduction in the water content (3).

Experiments carried out to determine the nitrogen fixing capacity of different legumes have shown that amongst the kharif legumes tried sann hemp showed the highest nitrogen fixation capacity (5).

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APPENDIX II, N.

(NOTES BY MAJOR A. H. SADIK, D.R.E. (OXON), *Director of Agriculture, Patiala State*)

(*a*) It has been found that usually the Farmyard Manure is mercilessly handled by the zamindars, resulting in a tremendous loss of its fertilising value. Urine is invariably completely lost. No doubt the Departments of Agriculture all over India are advocating the correct method of handling and storing of the farmyard manure but these recommendations need further vigorous and extensive propaganda. The burning of cow dung cakes has been a grave source of losing soil fertility. The systematical growing of fuel trees in village commons and recommending the burning of cotton sticks, etc., are a great help in checking this evil practice and this has been recommended with a fair amount of success by the Agriculture Department. Sometime ago cream separators were introduced to a few farmers as an experimental measure. It is found that it reduces the fuel demand of cow dung cakes to a great extent on account of not having to boil down large quantities of milk for the purpose of ghee making. The economic depression has been the chief cause against the quick adoption of this method for ghee making.

Synthetic manure has helped the farmers to a great extent in meeting their manure requirements. It has been found that where the zamindars have once taken to this practice they have greatly appreciated its value. Stalks of *Toria* and *Sarson* which were neither used as fodder nor fuel and were considered to be valueless, have especially helped to increase the quantity of synthetic manure.

(*b*) The value of green manuring is well established by now. About fourteen years ago His Highness the Maharaja Dhiraj of Patiala commanded the reduction in canal water rates to plane rates for the raising of green manuring crops. This concession has greatly popularised the adoption of this method of manuring. It is felt that further reduction in the rates for growing of the green manuring crops will be the best means of popularising this method. In Patiala State it has been observed that *Guara* as green manuring crop has proved superior to others.

(*c*) The artificial manures are only used to a small extent by the farmers. The chief reasons for this being:—

(1) The initial capital required for its application.

(2) The texture improving superiority of the farmyard manure.

It has been observed that application of artificial manure should only be recommended to the intelligent farmers and where there is a great dearth of farmyard manure.

APPENDIX II, M.

Soil amelioration—fertility of silt with special reference to silt of the Bengal rivers.

(D. N SEN-GUPTA, *Executive Engineer, Bengal.*)

Rice, is the main crop in Bengal The yield of crops in the flooded districts of Bengal is much more than what is normally obtained in the places where the crops get water from rain only This is further confirmed in the Damodar Canal area where the fields irrigated with the turbid water of the Damodar river produce a much bigger yield than the unirrigated fields, where rain is the only source of supply of water. Fertilising capacity appears to be different in different river silts. The Damodar seems to give the best fertilising silt amongst the Western Bengal rivers. The Ganges and the Brahmaputra on the East similarly appear to be better in this respect than the North Bengal rivers, such as the Teesta It is also found that the fields close to the river which receive a larger amount of silt (not sand) are more fertile than those further away where silt deposit is much less This is an important matter in the design of artificial irrigation channels In irrigation projects the fields intermediate between village channels are irrigated from field to field The channel can be designed with suitable sections to carry forward the silt and discharge it through the outlets But the flow over the fields is very slow and the silt in suspension cannot go far To properly distribute the silt over the fields, village channels should be sufficiently close to each other It is therefore of importance to study how far the silt can be passed from field to field in fairly good quantity.

(ii) The subject of the fertilising quality of silt does not appear to have received its due share of investigation In the Punjab and the other upper provinces fertilising of fields with flood water has not been studied on account of different riverine conditions

(iii) Regarding distribution of silt—there is no trouble in the flooded district where distribution is done in the natural course But there are places where flood is artificially prevented from spilling by marginal embankments along river banks and here necessity is felt for artificial irrigation In the upper provinces where lands contain more or less harmful salt, heavy irrigation is not considered to be always desirable. In Bengal the condition is different The soil is free from such salts and a large amount of irrigation during the rains with silt laden water is found to be beneficial both from agricultural and sanitary point of view In stagnant water, a kind of slimy scum is generally formed on the ground which is harmful to the crop. Outturn of crop is high in the flooded places Flood water passes over such fields in a slow but continual flow and prevents formation of such scum In artificial irrigation, for economy, the usual practice is to enclose the irrigation water within marginal embankments and keep it stagnant If by slow drainage of irrigation water, a much better result is obtained, such a method of irrigation should ordinarily be resorted to provided the supply is sufficient The study of this matter was not done in detail. Slow drainage of irrigation water will probably require larger irrigation channels and give low duty Unless definite advantage is gained, it may not be advisable to adopt the changed system A yield of 30—35 mds of paddy per acre is considered to be quite good in the irrigated areas of Bengal In the flooded districts of the province yields up to about 45 mds to the acre are not uncommon A similar yield is said to be obtained on the average in the irrigated lands in Japan In irrigated fields in Spain a much greater outturn is obtained How such good outturns are produced is a matter of great interest So far as the Irrigation Branch is concerned it is of particular importance if the method of irrigation (stagnant or flowing) has much to do with the better outturns.

(iv) Improvement of soil in Bengal may be done in different ways, such as,—

(a) deposition of fertilising silt

(b) application of artificial manure,

(c) sowing crops of different kinds in rotation—some fixing some taking up nitrogen from the soil, etc.,

(d) leaving fields fallow.

Bengal soil is so fertile that if it is treated properly under the methods (a) to (c), fields may not need to be left fallow. But the best method of such treatment for the different kinds of soil requires careful study

portion (or block as he called it) he assigned one plot to each treatment but strictly in a random manner. We have now the randomized block in its modern form. Using the principle of block division in two directions symmetrically we get the well known Latin square

Results Governed by Laws of Chance

The important point to be noticed is that the results will be now governed entirely by the laws of chance. There are innumerable causes which produce differences between the plots, and we know from the conditions of the experiment that it is impossible in practice to secure that the plots will be all alike *But the validity of* the estimate of error is now guaranteed by the process of randomization, namely "the provision that any two plots, not in the same block, shall have the same probability of being treated alike, and the same probability of being treated differently in each of the ways in which this is possible "[3] The calculus of probability and the apparatus of the statistical theory of sampling distribution can be now used with complete confidence. The logical foundations of scientific inference were thus made secure, and agricultural experiments were placed for the first time on the same footing as experiments in other sciences [4]

Elimination of Soil Differences

The second point to be observed is that by the technique of block division the problem of soil heterogeneity was solved at the same time As each block contains all the treatments once and once only, differences between the total yields of the different blocks could be safely ascribed, apart from errors of sampling, to soil differences; and could be eliminated by suitable statistical methods This of course led to a great improvement in the precision of the comparisons When we remember that in particular experiments in India as much as ninety per cent of the total variation is sometimes caused by soil differences, the importance of eliminating its effect will be easily appreciated

The Analysis of Variance

The third point to be emphasized is the close connexion between the field procedure and the procedure of statistical analysis in the Fisherian technique In fact they are merely two aspects of the same problem; "once the practical field procedure was fixed, only a single method of statistical analysis could be valid The specification of the particular process of randomization carried out, determined in advance the correct statistical analysis of the results "[5]

To sum up then, replication, randomization and block division (or local control) were the principles of design introduced by Fisher at Rothamsted, and were first described in 1923 in a paper on "the manurial response of different potato varieties "[6] Replication is essential because it is the sole source of the estimate of error, while randomization is necessary to guarantee the validity of the estimate, that is, to ensure that the estimate will be unbiased. The purpose of block division is to increase the precision of the comparisons by elimination of soil differences while replication is also useful in securing the same object by diminishing the experimental error Finally the analysis of variance* gives a convenient and valid method of extracting the information contained in the observations As Wishart has pointed out, the Fisherian technique "was something in the nature of a revolution," and altered the subsequent course of agricultural experiments throughout the world

Previous Conditions in India

It took some time before the new technique was introduced in this country. Seven or eight years ago in India the control used to be almost always repeated, but the

[3] *The Design of Experiments*, 1935, p. 71.

[4] In actual fact the statistical theory of exact distribution in terms only of actual observations, popularly known as distributions in "Studentized form", achieved a good deal more It made possible general conclusions being drawn with logical rigour from particular observations But this is a topic of statistical rather than agricultural interest and must be passed over here

[5] *Reprint from Rothamsted Report*, 1933, p. 5.

[6] *Jour. Agri. Sc.*, 13, 311-320.

* See Note on "variance", "standard error", "co-variance" etc.. at the end

APPENDIX III, A.

Notes on Subject VIII (A review of the application of statistical theory to experimental method in India so far as agricultural investigation is concerned).

A review of the application of statistical theory to agricultural field experiments in India.

(PROF. P. C. MAHALANOBIS, *Presidency College, Calcutta.*

INTRODUCTION.

I feel honoured in being invited to open the discussion on the use of statistical methods in agriculture in India. Although I had been asked to review the application of statistical theory to agricultural experiments of all kinds, I have thought it advisable, owing to the limited time at my disposal, to confine my remarks mainly to field trials. I have not therefore considered the many interesting and important applications of statistics in the laboratory experiments, genetic studies, agricultural meteorology, technology and other investigations I should also explain that, as I was obliged to prepare this note at short notice and in the midst of heavy pressure of other work, I have not attempted anything like a detailed survey; but have tried to describe the present position in its broadcast outlines. This is why I have avoided, as far as practicable, referring to individual papers or authors by name.

PART I GENERAL REVIEW OF THE PRESENT POSITION.

A review of the application of statistical theory to agricultural field trials in India in recent years is largely a story of the triumph of methods devised by R. A. Fisher at the Rothamsted Experimental Station. The new developments also bear remarkable testimony to the scientific vision of Sir John Russell, the Director of the Rothamsted Station, who had recognised as early as 1919 the need of the application of statistical theory to agricultural research, and had not only persuaded Fisher to take up this subject but had given him full scope and freedom for working out appropriate statistical methods in his own way

The basic principles of the new method are now well known and need not be discussed in detail. In order to appreciate the revolutionary advance brought about by the introduction of the new technique, let us however consider for a moment the contrast between experiments of the old and new type

THE OLD TYPE OF FIELD EXPERIMENT

Suppose we wish to compare the yield of say six varieties or the effect on yield of six kinds of manures In the old type of experiment the field would be divided into six plots, and a single plot would be allotted to each treatment As Fisher explains "the treatment giving the highest yield would of course appear to be best, but no one could say whether the plot would not in fact have yielded as well under some or all of the other treatments"[1] It is known that within the same field wide differences exist in the fertility of the soil Even when the soil fertility is uniform, there are innumerable other causes which affect the yield How can we be sure that the observed differences in yield are due to the difference in the treatments, and not to soil heterogeneity? How can we be sure that they are not due to chance fluctuations? This is the basic problem In order to solve it we must eliminate the effect of soil heterogeneity, and make an unbiassed estimate of the magnitude of errors due to chance so that we may be sure that the observed effect is significant in comparison with the size of such chance errors.

THE FISHERIAN TECHNIQUE

Let us now see how Fisher solved the problem. Consider the same experimental field which had been originally divided into six portions. Fisher simply further sub-divided each portion[2] into a number of plots of smaller size; and within each

[1] *The Design of Experiments*, 1935, p 69

[2] I need scarcely add that the experimental field may be divided into any number of convenient portions each of which is furth r sub divided into a number of plots

portion (or block as he called it) he assigned one plot to each treatment but strictly in a random manner. We have now the randomized block in its modern form. Using the principle of block division in two directions symmetrically we get the well-known Latin square.

Results Governed by Laws of Chance

The important point to be noticed is that the results will be now governed entirely by the laws of chance. There are innumerable causes which produce differences between the plots, and we know from the conditions of the experiment that it is impossible in practice to secure that the plots will be all alike. But the validity of the estimate of error is now guaranteed by the process of randomization, namely "the provision that any two plots, not in the same block, shall have the same probability of being treated alike, and the same probability of being treated differently in each of the ways in which this is possible."[3] The calculus of probability and the apparatus of the statistical theory of sampling distribution can be now used with complete confidence. The logical foundations of scientific inference were thus made secure, and agricultural experiments were placed for the first time on the same footing as experiments in other sciences.[4]

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The Analysis of Variance

The third point to be emphasized is the close connexion between the field procedure and the procedure of statistical analysis in the Fisherian technique. In fact they are merely two aspects of the same problem; "once the practical field procedure was fixed, only a single method of statistical analysis could be valid. The specification of the particular process of randomization carried out determined in advance the correct statistical analysis of the results."[5]

To sum up then, replication, randomization and block division (or local control) were the principles of design introduced by Fisher at Rothamsted, and were first described in 1923 in a paper on "the manurial response of different potato varieties."[6] Replication is essential because it is the sole source of the estimate of error, while randomization is necessary to guarantee the validity of the estimate, that is, to ensure that the estimate will be unbiased. The purpose of block division is to increase the precision of the comparisons by elimination of soil differences, while replication is also useful in securing the same object by diminishing the experimental error. Finally the analysis of variance* gives a convenient and valid method of extracting the information contained in the observations. As Wishart has pointed out, the Fisherian technique "was something in the nature of a revolution," and altered the subsequent course of agricultural experiments throughout the world.

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[4] In actual fact the statistical theory of exact distribution in terms only of actual observations, popularly known as distributions in "Studentized form", achieved a good deal more. It made possible general conclusions being drawn with logical rigour from particular observations. But this is a topic of statistical rather than agricultural interest and must be passed over here.

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[6] *Jour. Agri. Sc.*, 13, 311-320.

* See Note on "variance", "standard error", "co-variance" etc., at the end.

treatments were usually laid down without replication. Even when replication was used, it was of the systematic type and inadequate in number. In interpreting the results, the usual practice was to compare the means of the various treatments. In a few cases probable errors of means were calculated.[7] But in the absence of randomization, such estimates were not unbiased, and could not be validly used for purposes of comparisons. Finally there was no attempt to eliminate the effect of soil differences.[8] It is no wonder therefore that many of the inferences drawn from the old experiments were unreliable Even when the results were true, this could not be asserted with scientific precision "[9]

THE INTRODUCTION OF THE NEW TECHNIQUE IN INDIA

Like most other recent movements in agriculture in India, we owe the introduction of statistical methods to the Royal Commission on Agriculture[10] which had made definite recommendations on this point in 1928. In actual practice the modern period of field experiments began in India, I believe, with the foundation of the Imperial Council of Agricultural Research in 1929 on the recommendation of the Royal Commission. The earliest experiment of the new type, a varietal trial on rice with a 12×12 Latin square was reported in the Ind Jour. Agri. Sc. in 1931. The I. C. A. R. from its inception laid emphasis on statistical methods, created a statistical section at headquarters with a whole-time statistician at its head, and gave a grant to the Statistical Laboratory, Calcutta, for advanced studies and researches in statistics.[11] In fact I believe it was soon made a condition of all I C A R schemes that the experimental designs should be of the approved type The Statistician to the I. C. A. R. gives his advice on all standard schemes in the province, and personally visits a large number of farms every year. Help is also available, especially on the research side, from the Calcutta Statistical Laboratory In the course of this work a series of Statistical Notes for Agricultural Workers was started of which 23 numbers have been published so far. In 1932 arrangements were made in Calcutta for giving special courses of instruction in statistical methods to officers who were sent there on deputation for this purpose. During the last five years such training has been given to over 75 agricultural officers from all over India, which, I believe has helped materially in raising the general standard of work. The lead given by the I C A R in all these ways has resulted in the Latin square and randomized block designs being used with great success all over India. It is probably no exaggeration to say that no important experiment in India is now laid out on an old type design This must be considered to be a solid achievement.

FACTORIAL (COMPLEX) EXPERIMENTS

We may now consider some further developments of the new techniques As early as 1926 Fisher had advocated the use of factorial designs in which two or more types of treatments were laid out on the same field

Suppose we wish to compare three varieties, and the effect of three manurial treatments on each of these varieties If we conduct the experiments separately and use six replications, we shall require for the varietal trial $3 \times 6 = 18$ plots For the

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7 The ordinary formula in the classical theory of errors was used for this purpose This was inexact for two reasons: the observed variance was substituted for the corresponding population value, and the effect of a finite and usually small size of sample was ignored

8 It is of some personal interest to me to recall here that to this particular problem I owe my contact with agricultural work. In 1924, my attention was drawn by Dr W., Burns (offg. Agricultural Expert), then working in Bombay, to an experiment in which six varieties of rice were laid out in ten replicates systematically arranged side by side in long stripes. On the assumption of a systematic variation in soil fertility, it was ... the soil differences by graduation, and it was found that the precisic ... lerably increased. At that time I was quite u ... but Dr. Burn's problem soon made me get acq ... made me realize its great value. ... ed to be done in India a few years ago

9 So ... the Statistician to the I. C. A. R. in can be ... 1933.

10 Pp. 617-18.

11 I recall with gratitude that this was done mainly on the initiative of Mr. (now Sir) Bryce Burt, the Agricultural Expert (now offg. Vice Chairman, I. C. A. R.)

manurial portion we shall require three experiments dealing respectively with the three varieties. With six replications we shall therefore require 54 plots for the manurial investigations and 18 plots for the varietal comparison or 72 plots altogether.

Instead of simple experiments, suppose we combine them in one factorial (or complex) design. First of all, for nine combinations (3 varieties $\times$ 3 manures) we can then afford to give eight (instead of six) replications each in the same field of 72 plots. Secondly, we shall have no less than 24 replications available for the varietal or manurial comparisons; so that, if the standard error per plot remins the same, the accuracy of the main comparisons will be increased four times. Finally, the three manurial treatments cannot be directly compared in the separate experiments; but in the factorial design the comparisons would be completely valid. In other words, the differential manurial requirement of particular varieties that is, the inter-action between varieties and manures, if any, can be investigated only if the experiment is designed in the factorial form. With three or four factors the amount of information obtained is proportionately even greater. Besides the main effects, we can not only study the differential effect (or inter-action) of the factors two by two, but also the response of one factor in the presence or absence of two or more of the other factors.

A factorial experiment is thus not only more efficient in the sense that with the same number of plots all the factors can be studied with greater precision, but is also more comprehensive and will give information about differential response which could not possibly have been obtained by any number of experiments of the simple type. This is why Fisher definitely rejected the orthodox principle of varying the factors only one at a time. He said in 1926 "No aphorism is more frequently repeated in connection with field trials than that we must ask Nature few questions, or ideally, one question at a time. The writer is convinced that this view is wholly mistaken. Nature, he suggests, will best respond to a logical and carefully thought out questionnaire; indeed, if we ask her a single question, she will often refuse to answer until some other topic is answered." [12]

Before leaving this topic it is perhaps worth while pointing out a third advantage of the factorial design. In the orthodox method all the factors except one are deliberately kept approximately constant. In the result, information is obtained only for a narrow range of controlled conditions. In the factorial design on the other hand a number of factors are allowed to vary at the same time so that conclusions drawn from such an experiment has a much wider basis for induction.

In India the first factorial experiment with three varieties of potato under three manurial treatments was laid down at the instance of the Statistical Laboratory at the Visvabharati Institute of Rural Reconstruction at Sriniketan in 1931. During the last four or five years similar two-factor experiments have become quite common all over India. Designs with three or four factors are also being used with success. As an example I may mention the four-factor cultivation experiment with rice (three varieties, five dates of planting, three spacings and three numbers of seedlings per hole) designed at the Statistical Laboratory and conducted under the I. C. A. R. rice research scheme at Chinsurah for the four seasons 1933-37. The summary of results shown in the Appendix will give some idea of the wealth of information which can be obtained only from designs of this type.

In spite of their efficiency and comprehensiveness certain objections have been raised against the use of factorial designs which may be briefly considered here. It has been pointed out that the main effects are obtained with greater precision than the inter-actions, also that the experiment includes many combinations which are never likely to be used in practice. This is quite true but inevitable. When we have no knowledge as to what particular combinations are likely to be useful it is desirable that we should seek to survey the whole range of all the factors. But an extensive field of survey inevitably implies a lower level of accuracy. However as experience is gathered the field of enquiry can be narrowed by reducing the number of combinations with an automatic increase in the precision.

A second objection is more serious. With an increase in the number of combinations, the size of the block becomes too large for adequate elimination of soil heterogeneity with consequent increase in the residual error. The difficulty has been admirably got over recently by the "splitting of plots" and the "confounding of inter-actions."

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[12] The arrangement of field experiments. *Jour. Min. Agri.*, 33 (1926), 503-513.

Split-Plot and 'Confounded' Designs

In the factorial design complete *information about all the* combinations can be obtained at the cost of accuracy. We can however increase the precision by sacrificing a portion of the information This is just what is achieved in the "confounded" design. The whole array of *treatment* combinations is therefore not included in the same block, but deliberately distributed over two or more balanced sub-blocks. Experience has shown that high-order inter-actions are often insignificant, or even when statistically *significant are not of much practical* importance In the confounded design information about such high-order interactions is usually sacrificed to increase the precision of other comparisons. If we like we can, however, arrange to obtain some *information about all the interactions*, but inevitably at a lower level of precision, by 'partial confounding.'

The split-plot lay-out is a *simple* example of confounding in which the main effects of one of the factors are confounded. This design is particularly applied to small plots of the treatments are such that they cannot be conveniently applied to small plots *These main treatments* are therefore laid out in a randomized block or Latin square design, but each whole-plot is divided into a number of sub-plots which are allotted at random to the different sub-treatments The residual variance between sub-plots gives the appropriate error for the comparison of sub treatments, while the residual variance between plots gives the error for the whole plot treatments.

The split-plot design is being extensively used in India, but *the confounded design* has so far not attracted much notice. As far as I know, one elegant design prepared by Yates has been laid down at the Tocklai Tea Experimental Station, and one design has been supplied by the Statistical Laboratory to the Dacca University for the I. C. A. R. scheme.

The designing of confounded lay-outs is an interesting exercise, and in skilled hands it has attained a high degree of efficiency I would draw the attention of all agricultural workers interested in this subject to the discussion in *Fisher's Design of Experiments*, the *Rothamsted Reports* for the last few years, and the recent monograph by F. Yates on the *Design and Analysis of Factorial Experiments* [13]

The complete factorial design, we have seen, is both efficient and comprehensive But they need great care at every stage of the work, and with a large number of factors require blocks which are inconveniently large in practice There is, therefore, a limit to the usefulness of this type of design depending on the heterogeneity of the land, the number of factors and nature of the problem, the skill and experience of the investigator etc. The split-plot design is very convenient in problems in which knowledge about the main treatments are already available But I am of opinion that it is the confounded design which has the greatest possibilities in India, both on account of its flexibility as well as its economy of cost Caution is needed, however, both in designing the experiment and in carrying out the statistical analysis In the beginning it will be desirable therefore to use standard patterns under the guidance of statistical workers.

Interpretation of Results

Before leaving this subject I would like to add a few words in regard to the interpretation of the results. I have found that many agricultural workers are able to *reduce* the data correctly and complete the arithmetical part of the analysis of variance without however being able to draw the necessary inferences 'Significance' or 'non significance' are purely technical terms with the exact implication of which *every experimenter* should be familiar

Suppose we are working on the five per cent level of significance Then the rule is that any effect which is likely to occur by pure chance less than once in twenty times on an average *will be called "significant"*. On the other hand, effects which are likely to occur more frequently than once in twenty trials will be called "non-significant." Let us see the application of this rule in a concrete case. Suppose we have an experiment in which the *treatments do not* in fact produce any effect. Even then, with the present rule, the effect will appear to be significant in about once in twenty trials, and in the remaining 95 per cent. of cases we shall quite correctly decide the effect to be nil. *The risk of considering* an effect to be real, *when in fact it does not exist*, is thus limited to just five per cent. Similarly working at one per cent level of significance we limit the risk of our accepting a spurious effect as real to one per cent. In other words we work *with odds* of 99 to 1 in our favour.

13) Technical Communication No. 35 of the Imperial Bureau of Soil Science, 1937.

I may point out at this stage a peculiar property of statistical inference. Suppose we are working on the five per cent level. We have seen that even when the effect is nil, we shall judge it to be real once in twenty trials. In other words, if statistical theory is right, we must be wrong in our judgment in five per cent. of the cases. The possibility, or rather, the certainty of error is thus inherent in the structure of statistical inference. This knowledge is a salutary check against an exaggerated sense of our own infallibility.

The experimenter must therefore be careful in attaching undue importance to an isolated result which may appear to be statistically significant and yet does not fit in with the general agricultural experience. Such results should not be ignored, but should neither be accepted until corroborated by further experiments. On the other hand, results statistically insignificant should not be always neglected. If they appear to be plausible from other considerations, further investigations should be made with increased precision of comparison.

In short, the experimenter must use his critical judgment and discretion in the final interpretation of the results. Statistics is both indispensable and invaluable, but it cannot replace the human mind.

Precision of Indian Experiments

Having reviewed the broader features of the new technique, it will be of some interest to examine the precision attained in Indian experiments. I am sorry, in the limited time at my disposal, I was unable to collect relevant information from the different provinces of India. I shall therefore discuss this point with the help of materials from Bengal and Assam which were readily available in our Laboratory.

The average standard errors per plot (expressed as percentages of mean yields) for four or five careful series of varietal trials with *aus* and *aman* rice at Chinsurah Farm during the five seasons 1932-33—1936-37 are shown below. (The figures within brackets give the number of experiments on which the average is based).

Bengal : Chinsurah Farm Varietal Tests

(Standard error per plot as percentage of mean)

Year	Rice Crop.	
	Aus	Aman
1932-33	11·61 (3)	10·10 (5)
1933-34	9·68 (2)	10·06 (5)
1934-35	8·38 (3)	10·21 [illegible]
1935-36	[illegible]	[illegible]
1936-37	9·19 (2)	[illegible]

Similar figures for recent rice and sugar-cane experiments [illegible] 1932-33—1935-36 are given below.

Assam.

(Standard error per plot as percentage [illegible]

Comparative figures for English experiments are quoted below from the Report of the Rothamsted Experimental Station for 1935.

ENGLISH STATIONS.

Crop	Latin Square	Randomised Block	All Arrangements
Potato .	8·8	9·2	.
Sugarbeet .	6·1	7·9	
Swedes . .		..	6·9
Mangolds .	.	.	8·2
Kale . .		..	7 7

Wishart and Sanders are of opinion that a standard error of 5 per cent. for root-crops and of 10 per cent for cereals may be considered satisfactory[14] Judged by English standards, the work in Assam and Bengal is therefore not unsatisfactory. I have no reason to think that careful work in other parts of India is in any way less accurate.

LATIN SQUARE *vs.* RANDOMIZED BLOCK

Owing to the possibility of eliminating soil differences in two directions, one would expect the Latin square to be more accurate than the randomized block, and English experience has generally borne this out I am not in possession of enough data to judge the position in India My general impression is that the Latin square has been given preference here in small scale varietal work For large scale work, I think on the whole the randomized block has been used more extensively in India, no doubt on account of its greater flexibility. One advantage of the randomized block is that an estimate of error can be calculated separately for each comparison Yates has pointed out that "this is of great value when handling new and unknown material, or treatments which may produce large differences and even partial or complete failures In such cases the assumption of constancy of error variance is entirely unjustified, but in a randomized block experiment any treatment or treatments may be excluded and the analysis carried out on the remainder This is not true of either the Latin square or of confounded arrangements[15]

Complex or factorial designs in India apparently have a slightly higher standard error per plot (of the order of 10 or 15 per cent of mean yield) than the simple Latin square or randomized block. This is probably due to the experimental difficulties in managing more than one set of factors on the same plot and to large block sizes.

UNIFORMITY TRIALS

In a randomized block design the greater the homogeneity of plots within blocks the greater the accuracy of the experiment In practice this can be secured experimentally only to a limited extent. But sometimes it is possible to increase the precision of comparison very considerably by suitable statistical adjustments. Suppose, for example, that the initial fertility of plots is known from a previous uniformity trial in which the same variety is planted on all the plots and given the same manuring, and the relative fertility of individual plots remain fairly stable; then the yields in a succeeding year will be appreciably correlated with the yields in the uniformity trial. In this situation it is possible, with the help of the analysis of co-variance, to make allowances for the initial differences in fertility among plots within each block. The use of such adjusted yields can then be used for the final comparison This method has been sometimes known to have increased the precision even ten or twelve times.

[14] J. Wishart and H. G. Sanders: *Principles and Practice of Field Experimentation*, 1936 p. 93

[15] ——— J. R. S. S. Supp., 1935, p 222.

It should not be imagined, however, that this is always or even generally possible In fact with annual crops the fluctuations in fertility of the same plot from year to year are usually so great that the increase in precision obtained by this method is not in general commensurate with the expense or the delay of one season involved in a uniformity trial.

It is therefore usually unprofitable to conduct a uniformity trial as a preliminary to the main experiment with a view to increasing its precision. Repeating the actual experiment twice would most often give more information. This is why we have for a long time discouraged the adoption of a uniformity trial as a routine practice. It may be noted, however, that there are special circumstances in which such trials may be very useful indeed, for example, in the case of horticultural experiments.

Size and Shape of Plots

We may now consider the question of size and shape of plots As early as 1910 Hall harvested a wheat and a mangold field in small units, and found that the variation between plo ... the size reached was about 1/40 acre It was ther ... was corroborated by other uniformity trials, that ... somewhere about plots of 1/40 acre.

We have had occasion to examine the results of a number of uniformity trials in India, and we found that for varietal trials in many cases the plot could be reduced, so far as precision is concerned, to a very small size of the order of 1/140 acre. Plots of size 1/80 acre or 1/40 acre also give quite good results and can be safely recommended for convenience of agricultural operations Given the area, the question of shape or orientation comes in Christidis[16] showed from theoretical considerations as well as experimental data that long plots placed parallel to the fertility gradient gave the best results Our experience in India is also more or less similar Sugarcane experiments at Pusa and other places in North Bihar show that strips the length of which is ten or fifteen times greater than the width give more accurate results Rice experiments show the same tendency but to a smaller extent

Size of Blocks

The final precision of an experiment does not depend only on the best selection of plot size What is needed is a choice of the optimum combination of the size of both blocks and plots The best results will be obtained when the blocks are fairly homogeneous, (that is, all the plots within the same block have nearly the same fertility), but *differ appreciably as a whole between themselves* It is *obviously not possible* to give any limits for the block size If the soil is fairly uniform, it is possible to work with blocks of a large size, on the other hand if the fertility gradients are steep, the size of the blocks must be kept small I had the opportunity of studying in detail the variation in soil fertility of a field of about one acre under rice at the Chinsurah Farm, which was *harvested at my request in 7040 units of 9 inches by 90* inches (1/7740 acres). We tried many combinations of block and plot sizes, and found that a low standard error of about 3.5 per cent of mean yield per plot was obtained with a block size of 80′ × 44′ (about 1/12 acre) with 8 plots each of size 20′ × 22′ (1/100 acre). But considerably larger size of blocks 160′ × 44′ (or about 1/6 acre), or 160 × 88 (1/3 acre) with 8 or 16 plots each could be used with only a moderate increase in the error to about 5 per cent of *mean yield per plot*

Success of the New Technique

From the brief review given above I think it can be stated without hesitation that in India wherever the Fisherian technique has been used on proper lines in field trials, it has been found entirely satisfactory in every way and has given excellent results The working procedure is very flexible so that it can be adapted to suit the most diverse problems and conditions of work

A good deal of valuable information regarding soil differences and the relative accuracy of different types of experimental designs is also fast accumulating in India It is desirable in designing a new experiment that each *experimenter should utilise* all available information relating to his own work In this way he would be often able to get a good idea of the type of design likely to give the best results, and also to safeguard himself against too large a margin of error by using an adequate number of replications or other methods of controlling soil differences.

[16] *Jour. Agri Sc*, 21(1), 1931, 14-37.

Concomitant Variations and Correlational Analysis

I have already considered the use of uniformity trials, and I may now briefly refer to certain other methods of increasing the precision of field trials by using concomitant measurements and the analysis of covariance. The underlying principle is simple. In a field trial there are many other factors besides yield which can be studied, and it often happens that some of these factors are correlated with the yield in the sense that variations in such factors cause (or are associated with) variations in the yield. It then becomes possible to separate and eliminate that portion of the variation in the yield which may be ascribed to these factors. In this way the precision of the experiment can be often increased very considerably. For example, it may happen in a field trial that the yields of different plots are disturbed by variations in the number of plants which have established themselves. When such disturbances are due to causes which have no connexion with the treatments under trial, it is clear that there can be no objection to making allowances for such variations. In the present example, by counting the number of plants in the different plots, we can easily eliminate the variations in yield due to variations in plant number, and hence increase the precision of the experiment.

Similar methods may be used for eliminating the influence of varying intensity of attacks of pests and insects in different plots. It would be most undesirable to reject some of the yields simply because they appear to be too low. As Wishart and Sanders[17] have remarked, "once a start is made in rejecting actual figures, there is no knowing where to stop, ... a little skill in the game will lead to very significant, but quite untrustworthy results. There is no wish to impugn the reader's honesty, but no man is so virtuous that he can afford to treat temptation with disdain". The position would be quite different if some observations were recorded on the intensity of the insect attack in the different plots before the crop is harvested. Such records can then be used for making adjustments without bias.

The method of correlation or analysis of covariance can also be used with great advantage in other ways. If records of growth of the plant (height, girth, tillering, etc.) are kept at different stages, such records can be correlated with the final yield, and may be utilized to furnish valuable information on many points. These methods deserve greater attention than they have received so far in India.

Missing Yields or Plots

Before leaving the subject of field trials I may refer briefly to another question which occasionally arises in practice. Owing to accidents or negligence on the part of the subordinate staff, it sometimes happens that the yield of one or more plots are missing or get mixed up. In such cases it is often possible to reconstruct approximately the missing yields by purely statistical methods, and thus recover much of the information which would have been otherwise thrown away. Formulae for certain simple cases were given for this purpose originally by F. E. Allan and J. Wishart[18] in 1930, and a general solution was subsequently given by F. Yates[19] in 1933. Additions to the theory have been made in the Statistical Laboratory and have been used with success for certain types of mistakes which had actually occurred in India. It cannot however be emphasized too much that such procedures are at best make-shift arrangements, and the damage done by careless work cannot be repaired by such methods. In any case these methods must be used with very great caution.

The Use of Random Samples

The use of concomitant measurements usually involves a great deal of labour, which can be often reduced very considerably by adopting the method of random sampling. Consider an ordinary field trial. Suppose for any reason, shortage of labour or inclement weather or some other difficulty, it is found impracticable to measure the complete yield of each plot. In this situation we may take one or more random samples from each plot and measure the yield of these samples. Or consider the measurement of the height of plants at different stages of growth in the case of a field trial. For ordinary crops the number of individual plants in each plot is very large, and it is practically impossible to measure separately every plant in each plot. We may here take a random sample of the same number of plants in each plot, and

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17 J. Wishart and H. G. Sanders: *Principles and Practice of Field Experimentation*, 1936, pp. 97-98.

18 *Jour. Agri. Sc.* 20(3), 1930, 399-406.

19 *Emp. Jour. Expt. Agri.* 1(2), 1933, 129-142.

measure only those plants which are included in these random samples Sometimes complete enumeration is not only impracticable but even theoretically impossible. For example, if the dry weight of plants is sought to be studied at different stages of growth under different treatments, it is obvious that necessary measurements cannot possibly be carried on the same plants but only on portions of the material under observation. In such situations there is no other alternative but to have recourse to random sampling.

Fortunately, when used judiciously this method is quite efficient, and the additional error introduced by this method is usually small[20] The method of random sampling[21], has great possibilities which should be more fully explored in India.

Other Applications of Statistical Theory

I have considered field trials at some length as this is the main topic for discussion. But statistical methods have also been used with success in other types of work in this country some of which may be briefly mentioned at this stage

The principle of randomized replication has been used in pot culture, animal nutrition studies, experiments on incidence of pests, horticultural experiments, etc. Very recently it has also been used in sylvicultural experiments at the Imperial Institute of Forest Research at Dehra Dun.

Correlational analysis has been used in a number of investigations on the influence of rainfall and other weather conditions on crop out-turn, and although valuable results have been obtained, the scope of such studies has been unfortunately much restricted in India by the paucity of reliable crop data extending over a large number of years A good deal of valuable work is being done, chiefly under the auspices of the Meteorological Department, in agricultural meteorology in which statistical methods are being used extensively Modern statistical methods are being increasingly applied in linkage and genetic studies at the Indore Institute of Plant-breeding and elsewhere

More advanced statistical technique has been occasionally used for the investigation [illegible] quency distributions of cotton fibre in [illegible] the use of composite tests of signi- [illegible] nantitative measures of group diver- [illegible] etc In the limited times at our [illegible] profit such recent developments in detail.

On the whole, it may be said that agricultural workers in India have shown great readiness in using statistical methods, and have fully responded to the lead given by the I C. A R in this matter Given necessary guidance and facilities, there is every reason to hope that the use of such methods will steadily extend in India

PART II THE FUTURE PROGRAMME

Problems of Special Importance to India

We may now consider the future programme It was only natural that in the pioneer stage, much of the work in India followed closely the agricultural practice at Rothamsted and other English stations But with the valuable background of experience gained during the last six or seven years, and with the better organization of statistics in India, the time has come for using statistical theory and developing suitable methods for the study of problems of special interest to our country. A few suggestions in this connexion may be useful as a basis for discussion

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[20] In a field trial, for example, when the yields are obtained by random sampling, the effective error variance will be simply the sum of the variance between plots and the variance due to sampling Usually the latter will be considerably smaller than the former, so that the increase in the error will be small

[21] To be quite pedantic it should be called "random sampling from random samples" For, all statistical work is necessarily based on random samples The plot yields in a field trial, for example, are considered to be random samples from the hypothetical population of similar yields from the same plots under similar treatments in similar circumstances Complete enumeration here merely means measurement of complete yields of all the plots which together constitute one single random sample. In the method of "random samples", smaller random samples are taken from the plots.

Rainfall and Irrigation in relation to Agriculture

We are all familiar with the essential facts. Agriculture is the basic occupation, and the prosperity of trade, commerce, and industry are more dependent on it in India than in most countries of the world. The seasonal rainfall is concentrated within a comparatively short period, but fluctuates widely both in total amount as well as in distribution from year to year. A good monsoon with well-distributed rain usually means good crops and general prosperity, while a bad monsoon still causes, over a vast area, failure of crops and widespread distress.

Water conservation, irrigation, and drainage naturally constitute a subject of overwhelming importance, and I hope to be excused if I dwell at some length on this question. I have had the opportunity of studying in some detail the problem of rainfall and floods in Bengal and in Orissa. This has made me realize how great is its direct and indirect bearing on agriculture. In most parts of India, we have enough rainfall to produce sufficient food stuff for our present population. Our real problem is to conserve the water, prevent waste, distribute the available supply in the most efficient way over different areas and at different times according to agricultural requirements for the production of the optimum crop, and finally to drain away the excess without causing any mischief. Viewed in this way, irrigation, drainage, flood control, and agriculture are merely different aspects of the same fundamental problem.

We possess fairly satisfactory data about rainfall owing to the activities of an efficient Meteorological Department. We also have some, though neither enough nor quite reliable, data relating to rivers. But unfortunately the chief gap is in the agricultural knowledge.

Let me give a concrete example. I had occasion recently to examine a large irrigation scheme in Bengal which had the dual purpose of supplying water for crops at times of deficient rainfall, and of flood flushing the area as an anti-malarial measure. The future health, prosperity, and happiness of one million people depended on the success or failure of the scheme. We could estimate from past records with reasonable accuracy what deficiencies in rainfall were to be expected in future. We could also calculate how much water could be supplied from the Damodar river at different parts of the season. But unfortunately the agriculturists were quite unable to supply reliable information regarding the optimum water requirement of paddy. It was not possible therefore to make any estimate with confidence of the increased yield which might be reasonably expected with irrigation from the available supply. And yet this was the critical factor on which everything hinged. If the increase in production was sufficiently large the scheme would succeed, otherwise it would fail. The effect of a wrong decision either way would be disastrous. If the scheme were abandoned when in fact it might have succeeded, a great opportunity would be lost. If it were proceeded with but failed, such failure would prejudice for at least one generation the initiation of other schemes even when the prospects of success were great. I had to make the best of a bad job and tried to get round the difficulties by using statistical methods in a rather speculative fashion.

But that is a different story. To come back to our topic, we need these useful studies of the influence of rainfall and other climatic factors on crops. Such studies would be useful in two ways. First, for supplying badly needed information about the water requirement of crops. Secondly, for purposes of forecasting, even when a failure of crops cannot be prevented, early information may often enable ameliorative action being taken in time.

Permanent Climatic Series

It will be desirable therefore to start well-designed experiments in different parts of the country for studying the influence of rainfall and weather conditions on the yield of standard varieties of crops. The experiments will be definitely of the long-range type, and will be continued for many years. Arrangements will also be made for recording a number of carefully selected meteorological elements. In planning this series, the needs of the country as a whole will be naturally kept in mind, and the work will be standardized sufficiently to enable valid comparisons being made between results obtained at different stations.

Phenological Observations

The question of starting systematic phenological observations (such as earliest and latest dates of flowering of well-known plants, passage of migratory birds, advent of seasonal pests and insects, etc.) may also be given careful consideration

in the same connexion Such observations are likely to prove useful in many ways, not only in the study of seasonal variations of the weather, but in the control of pests and blights, and in throwing light on the behaviour of plants to environmental conditions

Irrigation Experiments

Well designed experiments will also have to be laid down for the direct study of water requirement and the growth of crops under irrigation In the first stage it will probably be desirable to conduct such experiments under conditions in which both the supply and the drainage of water can be controlled at desired levels As experience is gathered, it will no doubt be possible to approximate more closely to field conditions

In certain parts of India water logging and floods are often of almost as great importance as the lack of water Carefully designed experiments are therefore needed for studying questions of seepage, water-logging, etc, under actual agricultural conditions

Soil erosion is a problem of importance in many regions This question is closely connected with run off and drainage and requires to be studied in relation to irrigation. The possibilities of using, agricultural methods, such as planting of suitable crops of trees for controlling soil erosion, deserve investigation in the same connexion.

All these irrigation experiments, to give the best results, require the active co-operation of the engineer and the agriculturist, while the scope of using statistical methods is practically unlimited

Soil Studies

Another problem of great importance is the study of the soil and of the changes in its condition, in different parts of the country As regards progressive deterioration, the Royal Commission on Agriculture was of opinion "While paucity of records of crop out-turn throughout India over any long period of time makes the matter impossible of exact proof, we are of opinion that the strong presumption is that an overwhelming proportion of original lands of India long ago reached the condition to which experimental data point "[22]

Permanent Manurials

Careful experiments are needed to study whether soil deterioration is still progressing, and if so at what rate, and also to study the influence of different types of manures to prevent such deterioration and maintain the soil in a healthy condition. The time has therefore come to lay down a series of permanent manurials on modern lines at a number of selected stations Where practicable, the manurial series may be suitably combined with advantage with the climatic series

Multiple Experiments

Multiple experiments offer great advantages for the study of climatic, varietal, manurial, and other questions In this plan a number of experiments of the same type would be laid down with the same or similar groups of varieties or treatments in different parts of the country Owing to the large differences in soil and climatic factors, not only between different provinces but even in different districts of the same province, these experiments would be conducted under widely varying conditions

The work will have to be planned as a whole When the same set of varieties or manures or other treatments cannot be used in all the experiments of a given series, it should be still possible to link up the work by providing overlapping treatments through which comparisons can be made with confidence Standardization will obviously be necessary, but sufficient flexibility must be retained to adapt the work to suit local needs

If the multiple series is designed as a whole, it will be often possible to conduct a joint analysis of the results and to study the influence of the variations in the different factors. In this way valuable information might be obtained in a few years which would otherwise take a very long time to collect. In 1931 I had

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[22] Report of the Royal Commission on Agriculture (1928), p. 76

pointed out the need and scope of such multiple experiments under Indian conditions, and had pleaded for their adoption at the joint session of the Agriculture, Physics and Mathematics sections of the Indian Science Congress at Nagpur. Six or seven years ago the time was probably not ripe for undertaking such experiments on a large scale. But the Fisherian technique has now become so familiar that it should not be difficult to start them in the immediate future.

Cultivation and Rotation Experiments

Other problems of special importance in India are connected with methods of cultivation and rotation of crops. Given the soil and the water, the basic problem is to secure the greatest return to the cultivator. A wide outlook is desirable in designing such experiments. When we compare different methods of cultivation, for example, it is obviously not sufficient merely to concentrate attention on which method gives the largest yield of crop. It is also necessary to take into consideration the question of relative costs, the real aim being to find out which method will secure the largest net return to the cultivator. Similarly, in rotation experiments it is not enough to concentrate attention on merely the influence of a particular crop in one year on the yield of another crop in a succeeding year. The object should be to find out that particular sequence of crops which, after making allowances for differences in the cost of cultivation, would on an average secure the highest profit over a number of years.

Crop-cutting Experiments

Although crop cutting experiments do not fall under field trials, I would like to point out how such experiments may be made to supplement the information obtained from field experiments. Consider any given region. In an adequately designed crop-cutting experiment this region will be divided into a number of homogeneous zones with more or less the same type of soil, climate, irrigation facilities, type of crop, method of cultivation, etc. Suppose we now arrange to conduct the crop-cutting work at a number of spots selected strictly at random (but so arranged as to include all the varieties or conditions we desire to study) within each zone. The experiment as a whole will then resemble, on a very large scale, a field trial with a design of the randomized block type. I am not suggesting that in practice it will be possible to preserve the analogy in detail. But I think it should not be difficult to plan a crop cutting experiment as a whole in such a way as to supply useful information regarding the performance of different varieties or treatments under actual cultivating conditions on a large scale.

Apart from such considerations, a crop cutting experiment of course has its very important primary function of supplying information about the total out turn of crop. As the only method available here is that of random samples, this question offers great scope for the application of statistical theory. Valuable pioneer work has been done in the United Provinces in this connexion but the subject is of sufficient importance to deserve systematic and sustained study in the other provinces.

Place of Statistics in Agriculture

Before concluding I would like to make a few general remarks about the place of statistics in agriculture. It is I hope sufficiently clear from the previous discussion that the first function of statistical theory is to supply an adequate technique for collecting the primary data in such a way that valid inferences may be drawn from *them*. The use of the principle of randomized replication in some form or other is indispensable for this purpose. The second function is to extract the whole of the information contained in the data in the most efficient way. It has been already pointed out that the appropriate method for this purpose will depend entirely on the particular way in which the process of randomization is introduced.

We have seen how successfully these principles have been used in the case of field trials. It is essential that the same principles should also be applied in the case of experiments of all other kinds. There is great scope for work in this direction in India. For, I am afraid the need of statistical methods in experiments other than field trials has not yet been sufficiently recognized in this country. Much effort and time have been wasted in consequence.

Need of Definite Statistical Objects

In fact it would be a salutary practice in most experimental studies to refrain from taking any measurements or recording any observations whatsoever until one was satisfied that these could be utilized in a valid manner for *some* useful purpose.

In any case, it would be a safe rule to carry out a trial analysis with available material at the earliest opportunity. If this was done, it would often reveal gaps in the data or defects in the method of collecting them which could be often put right in time. If one waited until the end it would usually be too late.

Indeed in India it is tragic to see the enormous amount of statistical material which is collected at considerable expense but which is never used, or which can never be used in any way except as good for white ants. It would save a great deal of labour and money if no measurements or observations were recorded without a definite statistical purpose in view.

As already pointed out, in order to secure this end, the process of randomization and the projected method of analysis must be such that it would be possible to make precise statements as to the significance or non-significance of the results. When, as is usually the case, some previous information is already available, it is further necessary that the experiment should be designed in such a way that the expected precision is adequate for the purpose in view.

Statistics as a Tool and not the End

Even this is not sufficient, something more is necessary. Before starting an experiment each worker should satisfy himself that, if the experiment is successful, something will be gained which is worth the time, labour, and money spent on it. I frankly confess that I have sometimes wondered whether this condition had been really fulfilled in the case of some of the agricultural experiments which I have had occasion to examine. I know that this is treading on dangerous grounds, but I do not think it can be emphasized too much that statistics is merely a means and not an end in itself. Wishart and Sanders have wisely remarked: "In these days it is difficult, but very important to keep a sense of proportion over the question of experimentation. The statistical side has been given so much prominence in recent years that there is a real danger of statistics being regarded as the main interest in experimentation."[23]

Safeguards against Statistical Excesses

Agriculturists must not therefore allow statistics to degenerate into a kind of mysterious cult. The fundamental principles are easy to understand, and there is no reason why the experimenter should not take an intelligent interest in the designing of experiments. The statistician, owing chiefly to constant practice, is more skilled in handling certain technical tools which can be safely left to him. But it is the experimenter who is in a better position to judge the value of the experiment as a whole in its wider aspects.

Fortunately statistics itself may be used as a check against its own excess. It is possible, and possible only by statistical methods, to determine with scientific precision the marginal (or additional) cost in money and human labour obtaining any given amount of additional information or increased accuracy. In this way a kind of scientific cost accounting of experiments can be made possible, so that the experimenter may be guided in his decision by rational considerations.

Co-operation between Agriculturists and Statisticians

In India there is always a danger of our not being able to see the wood because of the trees. The only corrective is to keep the basic problem prominently in view. The experimenter should constantly remind the statistician (and also himself perhaps occasionally) that improving the standard of living of the 350 millions of our countrymen by increasing the produce of the earth is the ultimate aim of all agricultural experiments; and that how far progress is made in this direction is the final test by which all work will have to be judged. This is the only way in which the agriculturist will be able to breathe life into the dry bones of statistics. I therefore plead for a close, friendly, active and fruitful co-operation between the agriculturist and the statistician in this task.

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23 J. Wishart and H. G. Sanders; *Principles and Practice of Field Experimentation*, 1936, p. 60.

APPENDIX

MEAN SQUARES IN ANALYSIS OF VARIANCE · CHINSURAH COMPLEX EXPERIMENT ON RICE, 1933-36.

—	Degrees of Freedom	1933	1934	1936
Block	2	144098	330084	75533
Date of Planting	4	2389142**	499687**	5417487**
Error	8	39461	40555	23907
Variety	2	708517**	564263**	385807**
Error	4	12455	19494	16339
Planting × Varieties	8	29608**	37276**	26112**
Error	16	4239	8181	3018
Spacing	2	64848**	4061	10809**
Seedling	2	32691**	5733	2028
Spacing × Seedling	4	1396	3221	905
Planting × Seedling	8	2454	5370	1236
Planting × Spacing	8	5320*	1814	970
Variety × Seedling	4	1112	10710*	1065
Variety × Spacing	4	1306	4808	1331
Planting × Variety × Seedling	16	3991*	2559	1305
Planting × Variety × Spacing	16	2952*	5347	1771
Planting × Seedling × Spacing	16	1442	1585	848
Variety × Seedling × Spacing	8	1198	4634	1050
Planting × Variety × Seedling × Spacing.	32	947	2289	1779
Error	240	1364	2847	1882

*Indicates significance at 5 p. c. level **Indicates significance at 1 p. c. level.

Note.—The results are given for the three seasons 1933, 1934, and 1936 as the experiment failed in 1935 owing to drought. The test of significance indicates that the effects of the three varieties of rice, of the five dates of planting, and of their mutual interaction of the first order were appreciable in all the three seasons under observation. Variation of spacing also showed significant differences in 1933 and 1936 but not in 1934. Other effects were either insignificant or significant only for one season. A detailed examination showed that the variety called *Bhasamanik* gave the highest yields at Chinsura during all the three seasons. The first week of August was found to be the best date of planting; in fact the yield showed a distinct tendency to be lower if the transplanting was finished earlier or delayed by a fortnight. A close spacing and an increased number of seedlings per hole were necessary to insure against late transplantings particularly in years of adverse rainfall distribution. But under a favourable monsoon, small variations in spacing or seedling numbers produced practically no differences in yield. Finally, the superiority of one variety over another was not identical for all the dates of planting but was found to be significantly associated with the time of the transplanting.

NOTE ON VARIANCE; STANDARD ERROR; COVARIANCE ETC.

Let $x_1, x_2, \ldots \ldots x_n$ be the yields of x_n plots. Then the average yield is defined as $\bar{x} = \dfrac{x_1 + x_2 + \ldots \ldots + x_n}{n}$ .... (1).

The "deviation" (or "error") of the yield is simply the difference between any individual yield and the average, *i.e.*, $(x_1 - \bar{x})$, $(x_2 - \bar{x})$ etc. The "sum of squares of deviations" is given by $(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + \ldots (x_n - \bar{x})^2$ ... (2)

The "variance" of the yield is defined as the sum of squares of deviation divided by $(n-1)$, or

$$v = \frac{(x_1-\bar{x})^2 + (x_2-\bar{x})^2 + \cdots\cdots + (x_n-\bar{x})^2}{(n-1)} \qquad (3)$$

Here $(n-1)$ represents the "degrees of freedom" which can be usually identified with the number of independent comparisons possible in any given case. In the present example, we can clearly have $(n-1)$ independent comparisons between the yields of (n) different plots.

It will be noticed that "variance" represents a kind of average of the squares of deviations. The "standard deviation" or "standard error" is defined as the square root of the variance (which is sometimes also called the "root mean square deviation" or "root mean square error").

The variance defined in equation (3) is the variance of individual plots, and the corresponding standard deviation or standard error obtained by extracting the square root is the "standard error per plot."

The "variance of the mean" of the yields that is of $\bar{x}$ is obtained by dividing the variance of individual plots by n, the total number of plots concerned, *i.e.*, is given by

$$\frac{v}{n} = \frac{(x_1-\bar{x})^2 + (x_2-\bar{x})^2 + \cdots\cdots + (x_n-\bar{x})^2}{n\,(n-1)} \qquad (4)$$

The "standard error of the mean" is the square root of the above expression.

When more than one character (or variate) is present, the covariance of any two characters (or any two variates) is similarly defined as the sum of the products of the corresponding deviations divided by the degrees of freedom. Thus if (x_1, y_1), (x_2, y_2), ... (x_n, y_n) are the n pairs of values of the two characters, and $\bar{x}$ and $\bar{y}$ their respective averages, then the covariance is given by —

$$\frac{(x_1-\bar{x})(y_1-\bar{y}) + (x_2-\bar{x})(y_2-\bar{y}) + \cdots\cdots + (x_n-\bar{x})(y_n-\bar{y})}{(n-1)} \qquad (5)$$

Main effect and interaction.—If we have p treatments (or factors) then the main effect of each treatment (or factor) is the mean value of the relevant treatment (or factor) for all combinations of the other factors. The main effect is thus obtained by taking the average over all plots in which this particular factor occurs.

When two or more factors or treatments are used at the same time as in complex (factorial) experiments, the total effect due to the joint influence of two (or more) factors may or may not be equal to the sum of the effects due to each of the factors taken separately. Interaction between the factors is defined as the magnitude of the departure (if any) from the total effect calculated on the additive hypothesis. When the different factors act independently the joint effect will be necessarily additive, and the interaction will be consequently nil.

In an experiment involving p factors we can consider the factors in pairs, and we shall have one first-order interaction corresponding to each pair, or $\frac{p\,(p-1)}{2}$ first order interactions altogether. We can also consider the factors by threes, and in this case, if the first-order interactions are affected by the presence of the third factor, then we shall get second-order interactions. In the same way we can also consider higher order interactions but usually high order interactions are of little practical importance.

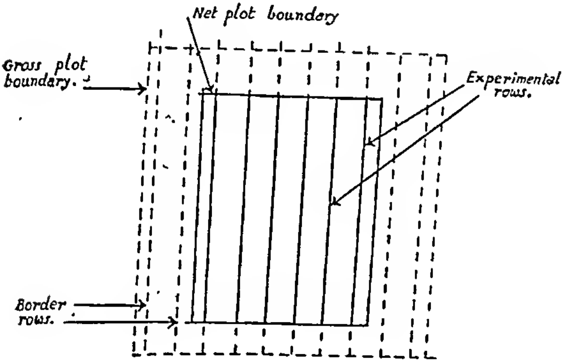
APPENDIX III, B.

A note on spacing experiments.

(S. S IYER, M.A., *Imperial Council of Agricultural Research*)

Spacing experiments form a main item in the agronomic programmes in most of the schemes of the Imperial Council of Agricultural Research. Very often the method of lay-out adopted is either incorrect or is capable of improvement.

Before discussing 'spacing experiments' it appears necessary to define the 'plot' as the problem is mainly one of fixing a suitable plot size In the figure is shown the plan of a complete plot with all the details.



Gross plot 20′ × 44′ 3″ with 10 rows 2′ apart.

Net plot 12′ × 36′ 3″ with 6 rows 2′ apart (1/100 acre).

Borders 2 rows on either side and 4′ at ends of each plot.

'*Gross plot*' is the total area for the application of a treatment Within this area the treatment should be applied evenly

'*Net plot*' is the ultimate area for 'plot yield' It is the area of the gross plot which remains after the exclusion of the borders

Border rows.—These are rows within the gross plot receiving the same treatment as other rows but are rejected to avoid any bias due to competition and trespassing effects It will be noted that end borders of the same width as side borders have also been marked This is very important but is often overlooked.

Of the two types of spacing experiments spacings between rows and spacings within rows, only in the former the plot size and borders are to be specially adapted. If we consider a simple type of spacing experiment with two spacings 6" and 12" and a plot size as shown in figure 1, there will ultimately be 24 experimental rows 6" apart and 12 experimental rows 12" apart (each 36' 3" long) within a net plot of each treatment. The *side borders* will be 4' in both the spacings i.e., 8 rows at 6" and 4 rows at 12" on either side of the plot. The *end borders* will also be 4'. In this instance the gross plot sizes as well as the net plot sizes for the two treatments will be alike. When the spacings between rows are large as in (American) 'cotton' and 'sugarcane', and when the number of spacings to be tried is also many, there will be the difficulty of accommodating a certain number of rows within the same plot size. For example, if spacings of 2', 2½', 3' and 3½' are to be tried in an experiment, the net plot should have a width of at least 210' (the least common multiple of 2', 2½', 3' and 3½') with 105 rows at 2', 84 rows at 2½', 70 rows at 3' and 60 rows at 3½'. A plot with this width is naturally out of question. Further, if in addition, the gross plot sizes are also to be equal, the width of the border will have to be 210' on either side. It is in such instances that faulty experimentation is common. Two methods which are generally adopted in some of the schemes of the Imperial Council of Agricultural Research are :—

(1) Using different net plot sizes for the different spacings and converting the plot yield to a common plot size for the purpose of calculations.

(2) Putting down as many rows as the plot could accommodate of each spacing.

The first method is often adopted in the spacing trials with sugarbeet at Rothamsted. But the differences between the spacings are often only 3" to 4" and the plot sizes vary within very narrow limits. In the second method also the plot sizes are unequal. For example, let us assume a net plot size of 12'×36¼' or 1/100 acre in which two spacings 3' and 3½' are to be tried. 4 rows at 3' can easily be put in while only 3 rows at 3½' can come in. The plot width in the latter case will become 10½'×36 or 1/114 acre.

One solution in cases where the plot width has to be increased to an impracticable extent is to omit those spacings which necessitate such increase. In the instance mentioned above the omission of 3½' spacing will reduce the width of the net plot to 30' taking *15 rows at 2, 12 rows at 2½'* and 10 rows at 3'. By omitting 2½' a width of 42' will be sufficient. Thus some preliminary experimentation appears to be necessary before a spacing experiment is conducted on the strictly randomised block type. The actual spacings as well as the number of different spacings to be tried should be selected so that a proper lay-out could be designed. After all, it may not be necessary to lay-out 1', 1½', 2', 2½', 3 and so on in one experiment. Two or three spacings which appear to yield equally or slightly different in a preliminary experiment could be tried on the randomised block type to bring out the results conclusively. One argument against this suggestion would be that the experimenter should have the choice of trying any spacing required by him. Considering that in modern field experimentation, the experimenter has to plan his experiments to allow of valid interpretation of results, it is no use overlooking such restrictions. In complex experiments the necessity of a judicious selection of spacings is more evident than in simple experiments.

The important point to be remembered is that in spacing experiments it is absolutely necessary that the net plot sizes are equal in *all* treatments. Adoption of equal gross plot sizes will mean huge gross plots and rejection of a large area by way of borders. This difficulty cannot be obviated by conducting the experiment without borders altogether. One way of solving this difficulty is to have the same net plot size for all treatments and sow one or two rows extra on either side with the same spacing as the inner rows. This will give different gross plot sizes. But the experimenter is concerned only with net plot yields. There will, however, be extra field work in laying out plots of different sizes.

Borders.—A word about 'borders' and 'border effect' appears necessary as they are not clearly understood by some experiments. An *un-sown space* or one or two lines of plants grown between two plots do not form 'borders'. Their rejection cannot eliminate the 'border effect'. Due to competition and trespassing effects the edge rows of each plot are influenced by the treatment of the adjacent plot. An un-sown area may eliminate competition between the adjacent treatments but the edge rows of the adjacent plots will still be in a different environmentent compared to the inner rows. It will be clear that to avoid the 'border effect' the edge rows

which form part of the plot (gross plot) and which receive the same treatment as the inner rows should be rejected. When this is done there is no necessity to provide unsown area or one or two lines of untreated plants.

To summarise the main conclusions reached in this note :—

(1) In spacing experiments due care has to be taken that the net plot sizes *i e.,* the ultimate experimental plot sizes should be *equal* for the different treatments

The gross plot sizes may be equal or unequal as circumstances permit.

(2) To avoid 'border effect' it is necessary to omit 'border rows' on either side and at the ends. It is no use leaving either non-experimental margins or blank spaces

APPENDIX III, C.

A case for the adoption of confounded designs in agricultural research in India.

(S. S. BOSE, *Statistical Laboratory, Calcutta.*)

The advantages of factorial experiments are now widely appreciated in this country. The difference between a simple experiment and a factorial experiment is this that while in the former, factors are made to vary one at a time, in the latter a number of factors are varied simultaneously in one compact arrangement. Thus, a design containing three different doses of nitrogen or phosphate repeated over, say five randomised blocks, would be a simple experiment while another one containing nine combinations of three doses of nitrogen and three doses of phosphate would be a factorial experiment. The layout is otherwise the same. The advantages of factorial designs over the simple ones are two-fold. (1) Greater efficiency in that these factors (N and P) are evaluated with the same precision by means of only a fraction of the observations that would otherwise be necessary. (2) Greater comprehensiveness in that in addition to the effects of single factors their possible interactions are evaluated. There is a third advantage namely that the conclusions of a factorial experiment have a much wider inductive basis than those from a one factor test.

These advantages are well-known but practical difficulties arise as the number of factors are increased from two to three or from three to four. Thus with two variants of each, a three factor arrangement requires 2^3 or eight treatment combinations; with three variants, the number is 3^3 or twenty-seven combinations and with four, the number of treatment combinations are no less than sixty-four. Thus the block must contain eight plots for two variants, twenty-seven for three variants and sixty-four for four variants. If we work with plots of 1/40 acre, the size that is frequently used, each block size would be about 1/5 acre for two variants and more than an acre and a half for the four variants. It is obvious that such large block sizes are not only often difficult to secure in an experimental farm but the soil heterogeneity between different portions of such a large block would give rise to a high experimental error resulting in a poor over all efficiency of the test as a whole.

One way out is naturally to reduce the plot size. But even then leaving aside the case of four variants, we need a plot size of 1/108 acre to accommodate twenty-seven plots in a block of a quarter of an acre. This is undoubtedly a very small area, often difficult to manage for purposes of ploughing and other cultivation operations. To meet this difficulty, the split-plot arrangement consisting of whole-plot and sub-plot treatments were developed. But a more powerful method is the confounded arrangement. This is extremely suitable to meet the increasing demands of modern agricultural research and at the same time to maintain a high standard of precision.

The use of confounded arrangements is based on practical considerations of usefulness and economy. Fisher has explained the position in this way. "A factorially arranged experiment supplies information on a large number of experimental comparisons. Some of these, such as the effects of single factors, will always be of interest. It is seldom, too, that we should be willing to forego knowledge of any interactions which may exist between pairs of these factors. But in the case of interactions involving three factors or more, the position is often somewhat different. Such interactions may with reason be deemed of little experimental value, either because the experimenter is confident that they are quantitatively unimportant, or because if they were known to exist, there would be no immediate prospect of the fact being utilised. In such cases we may usefully adopt the artifice known as 'Confounding'." (Design of Experiment, p. 116)

It is not difficult to apply this principle in practice. The whole set of treatment combinations is divided into two or three or more groups such that the contrasts between them shall be the contrasts between interactions that are considered unimportant. These groups are then allotted to different sub-blocks within each block. The difference between sub-blocks within block now gives the measure of the

interactions that are being sacrificed; in other words, the arrangement is such that some of the interactions are deliberately confounded with the sub-block differences.

Consider the case of a 3×3×3 arrangement in which we propose to confound the second order interaction. The block of twenty-seven plots is divided into three sub-blocks of nine plots each. Three suitably chosen groups of nine treatments each are then allotted to them, the position of treatments in each sub-block being obtained at random. Such an arrangement is shown in Fig. 1

Sub-block 1.	Sub-block 2.	Sub-block 3.
a_1 b_1 c_1	a_1 b_2 c_1	a_1 b_3 c_1
a_1 b_2 c_2	a_1 b_3 c_2	a_1 b_1 c_2
a_1 b_3 c_3	a_1 b_1 c_3	a_1 b_2 c_3
a_2 b_2 c_1	a_2 b_3 c_1	a_2 b_1 c_1
a_2 b_3 c_2	a_2 b_1 c_2	a_2 b_2 c_2
a_2 b_1 c_3	a_2 b_2 c_3	a_2 b_3 c_3
a_3 b_3 c_1	a_3 b_1 c_1	a_3 b_2 c_1
a_3 b_1 c_2	a_3 b_2 c_2	a_3 b_3 c_2
a_3 b_2 c_3	a_3 b_3 c_3	a_3 b_1 c_3

Fig. 1. Scheme of a Confounded Experiment with three factors a, b and c, each in three stages of abundance 1, 2 and 3. (The second order interaction is confounded with sub-block differences.)

The three sub-blocks taken together contain the twenty-seven possible combinations of three factors but instead of putting the whole set in one block of twenty-seven plots, these have been divided into three sub-blocks of nine plots.

In grouping the twenty-seven treatments into three portions, it was decided to sacrifice the second order interaction between a, b and c, but to keep intact all informations regarding the primary responses as well as the mutual interactions between them in pairs. The formula for this procedure may be stated as follows:— In each sub block (i) the three levels of each ingredient must be represented by three plots each, and (ii) the nine combinations of each pair of ingredients must be represented by one plot each.

Such a division is shown in Fig. 1. In this particular case of a 3×3×3 arrangement, there are eight degrees of freedom for the second order interactions. The sum of squares between the three sub blocks in Fig. 1 gives two degrees of freedom out of the eight. It is possible to divide the twenty-seven combinations into three groups by four different ways. Each of these ways accounts for two degrees of freedom and thus if we take up four blocks for the experiment as a whole, we may confound the two out of eight degrees of freedom belonging to the second order interaction in each block and thus distribute the confounding over the whole experiment of 108 plots.

The method of distributing confounded degrees of freedom among the various blocks is called Partial Confounding. This has the additional advantage that from each set of three blocks, some information regarding the second order interaction may be recovered. The statistical reduction of data in confounded design is necessarily altered to suit the changes in the layout but with a little bit of practice, one can pick up the method of analysis in the case of simpler arrangements.

During the last five years, the methods of confounded designs have been extensively used and has been found to be very efficient. At Rothamsted there is now an increasing use of confounded arrangements. Careful thinking is required in preparing such designs, for, the experimenter must make up his mind as to the factors and interactions which might lead to useful informations and also inter-

actions that may at that stage be sacrificed. Given this, the statistician is in a position to draw a plan to suit the needs of the agriculturist in all their detail.

In 'confounded' designs the block size would be considerably reduced and consequently heterogeneity effectively controlled. At the same time, the great advantages of a factorial experiment namely its comprehensiveness, its wide inductive basis and its efficiency would be all preserved.

In the interest of information and precision, it is therefore suggested that the use of confounded designs should be encouraged in all important agricultural stations of India. One word of caution is however necessary. The design and analysis of confounded experiments involve a critical knowledge of the inner structure of the factorial designs and slight inaccuracies may render the experiment completely invalid.

APPENDIX III, D.

Sampling technique for juice quality of the cane crop.

(NOTE RECEIVED FROM THE GOVERNMENT OF BIHAR.)

INTRODUCTION.

One of the important pre-requisites for arriving at an accurate data for juice quality of the cane crop in a field is the sampling technique employed for the purpose. Enquiries from various sources were made early with the establishment of the Research Station in the Province and the technique employed at those agricultural stations was tested and was found to give high variation when the sucrose values were compared with those of the entire plot crushed and analysed. Necessarily, therefore, a deviation from the procedure employed was called for and experiments were initiated in the line.

RESUME OF THE EXPERIMENTS

With a view to systematise the sampling technique, in the first instance stalk and clump variations were worked out. It was meant to show which of the two would serve better method of sampling a field These determinations were made during early, mid and late seasons Since stalk variations, as will be evident from the data presented later in the text, were more pronounced, it was considered that a further detailed study was called for and, therefore, deviations from mean sucrose values amongst stalks of 'a', 'b' and 'c' order (Barber—Agr Memoirs—Bot series—1920) were worked out. These were only worked out on the 16th December 1933 But clump sampling was done during early, mid and late seasons The variation was studied from single, two, three, etc., to ten clumps per plot of 1/40th of an acre standard size employed for experimental purposes The procedure adopted for drawing the clump samples from experimental plots was as described below For determining which clump or clumps in a plot should be cut, number of clumps likely to be met with in each of the row of a plot were written on small slips and these were well shuffled and a slip drawn out of it The drawn number represented the clump to be cut from the labelled side of the plot Where only one clump was to be drawn that clump represented the plot but where more were required the same number of chits were drawn and clumps harvested Each of the clump was cut flush with the ground and only the crown of leaves was topped After carefully separating the remaining leaf sheathes and the dead leaves and cleaning the roots the canes were crushed and juice analysed. The results obtained are summarised later in the text

Although clump sampling showed more consistent results than the stalk sampling, the loss of material involved particularly in cases of weekly and fortnightly programme of analysis was considerable. Therefore, to avoid cutting large mass of material, a new technique comprising the use of hand refractometer and the hypodermic syringe was worked out. Fifty stalks in a plot, 1/40th of an acre were marked at random in clumps, lots for which were drawn in the manner described above Refractometer brix readings of 3rd, 4th, 5th and 6th bottom internodes were recorded and mean for each stalk worked out separately Three, four, five . to ten stalks respectively having mean values very close to the mean brix readings of the fifty stalks were harvested, crushed and analysed. The data thus derived gave interesting results Later on in connection with refractometer studies it was found that the method of taking brix from bottom four internodes, 3rd to 6th internodes, gave higher coefficient of variation than the method of taking brix from the top dead leaf internode and the bottom visible internode. This was, therefore, adopted for studies in sampling technique described above.

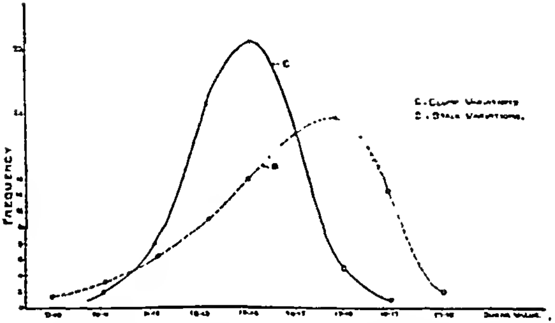
SUMMARISED RESULTS

The deviations from mean sucrose values for randomised clump and randomised stalk sampling are given in Table I and their frequency distribution is shown in Fig. I.

TABLE I

[illegible]

Date of sampling	Randomised clump sample.	Randomised stalk sample
23rd November, 1933	0.642 ±0.295	1.32 ±0.465
4th March, 1936	0.526 ±0.180	0.642 ±0.322



The data and the graph are self explanatory. Randomised clump sampling is evidently a better method. Early in the season the variations in both cases are more pronounced than late in the season which tend to decrease more rapidly in randomised stalk samples than in randomised clump samples. Maturity of the stalks seems to be mainly responsible for such a wide variation as will be evident from Table given below :—

TABLE II

VARIATION BETWEEN STALK OF 'A', 'B' AND 'C' ORDER—VARIETY Co 213

Order of stalks.	Nature of variation.	Remarks.
Stalks of " A " order	0·41 ±·037	The experiment was conducted on December 16th, 1933.
Stalks of " B " order	0·93 ±·131	
Stalks of " C " order	1·95 ±·277	

Stalks of 'A' order gave very low variation compared to that of 'B' or 'C' orders. Naturally, therefore, stalk variation is of such an order that greater reliance can only be placed when a sample consisting of a large number of stalks is taken into consideration.

As has already been mentioned clump sampling (Table I) showed a smaller variation compared to stalk variation. As such, therefore, clump sampling was taken as the method that would yield reliable results. The experiments were continued for three seasons, 1933—1936 and the results indicate that in normally grown plots randomised seven-whole clumps sample in the early part of the crushing season, *viz.*, early November to end December and randomised three whole clumps sample in the latter part, *viz.*, beginning of January onwards taken at different points in a plot, 1/40th of an acre, reduce considerably the personal and other errors and ensure reliable results

For experimental plots especially where comparative juice qualities of varieties or treatments are desired the method of stalk sampling by means of hand refractometer proved more suitable Working out of the method showed that sampling of fifty stalks at random and selecting even three stalks for a sample giving brix values close to the mean of 50 readings gave sucrose values very similar to those when the entire plot was harvested and crushed at a time. The coefficient of variation was still lower in this case than the three-whole clumps or seven-whole clumps samples. The method of arriving at mean brix ultimately adopted was by taking of the brix readings of only the top dead leaf internode and the bottom visible internode

Besides the reliability of the results obtained by this method the great saving in the cane material as already pointed out above is an extra gain

Since Hand Refractometer is not used at the Farms, for the present, method of clump sampling has only been given out The instructions issued in that connection are given below :—

INSTRUCTIONS REGARDING SAMPLING OF CANE AT THE FARMS IN BIHAR AND ORISSA

The work on the technique of field sampling has shown that in normally grown plots (as is the case at the Farms) randomised seven-whole clumps sample in the early part of the crushing season, *viz.*, early, November to end December and randomised three whole clumps in the latter part, *viz.*, beginning of January onwards taken at different point in a plot of 1/40th of an acre reduce considerably the personal and other errors and ensure reliable results Their adoption in place of the method or methods already in vogue at the farms is, therefore, recommended The following instructions will it is expected, make the new procedure to be followed easily intelligible to the Farm staff

1. Sample only the 'ultimate plot' discarding the outer one row on either side and six feet border each on the other two sides to eliminate the 'border effect For instance, a plot of five rows should have the central three rows sampled

2 For determining which clump or clumps in a row or plot should be cut write down on separate piece of paper the number of clumps likely to be met with in each row giving both the number of clump and number of row on each chit, shuffle them well and draw; the drawn number being always counted from the labelled side Thus drawn number twenty-third row I means twenty third clump from the side which is labelled in the first row and so on It may be pointed out that it is not necessary to individually count the total number of clumps in a row before drawing lots Rough idea as to the likely number of clumps to be met in one chain or two chains length of row is enough.

3. Do not discard any of the clumps because they are poorly grown

4. Cut the whole clump flush with the ground, top them at the usual point (neither too high nor too low) in each case, but do not strip them label and send to the crushing mill.

5. Strip the stalks *just before* they are to be crushed, properly removing attached roots, soil particles, etc.

6. All the canes in a sample should be crushed under as uniform conditions of setting of the rollers and speed of the bullocks as possible

7. Reject the first few c c of the juice from each sample It is very important and the Farm labour should be trained to feed in equal number or numbers, the top and butt ends of the cane stalks in the mill, so that the 'rejection' is not from top or bottom internodes alone

8 Weigh the juice and after thorough mixing send a representative 1 lb sample properly labelled, for analysis as soon after crushing as possible

II. Where the plot is big the number of clumps taken will depend upon the variation that is met with in the field In one acre field where variation was visibly not marked three independent seven-clumps samples drawn individually from different random sites and analysed separately gave a very reliable measure of the maturity of the crop

APPENDIX IV, A.

(i) Notes on Subject I. (A review of soil survey work in India up-to-date with suggestions for the future).

[NOTE BY DR J. K. BASU, *Soil Physicist, Sugarcane Scheme, Bombay Deccan, Padegaon*].

(I) REVIEW OF WORK

The literature on soil surveys and related subjects in India is vast and it would not be possible to do justice to all the available work in a short note. In order to bring out the salient features, however, it is thought desirable to classify the work into four broad groups according to the nature of the subjects and methods adopted therein. A somewhat similar classification has been used by the Russian soil scientist Tulaikoff (1) in discussing the soil survey work of the world. The classification proposed to deal with the Indian literature is enumerated below .—

(1) *The Applied classification* which is based on the suitability of soils for certain crops obtainable from the local cultivators

(2) *The Geologico petrographical*, in which the soils are grouped according to the geological petrographical character of the rocks which make up the soil

(3) *The physical and chemical classifications* according to the main chemical and physical (including mechanical) features of the surface and subsoil.

(4) *The Genetic Classification* by which soils are divided into groups depending on their origin and development In this system the soil profile is taken as a unit of study.

(1) *The Applied classification*.—This system of soil classification is mainly used by the Settlement Officers in various parts of India for the purpose of land assessments and is probably the earliest in the history of soil survey in India The classification is based on crop yields and related obvious soil properties which determine the soils' power of imbibing and retaining moisture A quotation from Mollison(2) will illustrate the system followed in the Deccan—"According to this system all soils are ranged under nine classes and three orders. The depth of the soil decides the class, whilst the colour and consistence determine the order The need of so many sub divisions is especially necessary in the Deccan where owing to the broken character of the country the soils are very variable." Systems followed in different parts of India are different and the basic factors used for classification are such as to suit the local conditions only However, very valuable informations regarding the productivity of different soils and their suitability for various crops may be had from these accounts

(2) *The Geologico-petrographical classification*.—This system originated with the German school of soil scientists who regarded soils mainly as decomposition products of rocks and ignored the very important influences of climate and vegetation on the processes of soil formation It was mainly due to the peculiar nature of the country where the variations in parent materials and geology are of great magnitude whereas the climate remains the same throughout the country and hence the former factor practically determines the nature of soil formation This geologic view point of soil formation in India was put forth by various workers of the Geological survey of India (3), (4), (5), (6), (7), (8), (9), and without doubt forms an important contribution to our present knowledge of the soils of India This subject has been dealt with by Oldham (10) in his book on Indian Geology and recently by Wadia and others(11) who have reviewed the problem in a very thorough going manner with an elaborate bibliography

(3) *The Physical and Chemical Classifications*.—These methods have been very extensively used in England and America prior to the introduction of the modern genetic system of soil classification This school looked upon soil in close relationship with plant growth This "agronomic" viewpoint sought the mysteries of chemical reactions in soils The soil was to them the "test tube" in which one might introduce the chemical ingredients for plant growth The chemical composition of the plant was the criterion by which one would judge the soils This view point was prevalent in India in most of the soil survey work till recently A huge amount of literature is available and it could be only feasible to deal with the important features of some work only in this connection.

Soil surveys under this head are in the nature of soil reconnaissance They are usually of two types: (A) Soil surveys from the "agronomic" viewpoint deal with the plant food requirements, mainly, nitrogen, potash, phosphoric acid and lime for studying the suitability of different soils for crops; (B) Surveys in connection with irrigation

projects, however, have other objects in view and the soils are analysed for physical properties connected with drainage, chemical determinations like soluble salts, soil reaction, exchangeable basis etc Although the soils are examined to a much greater depth in the latter case than in the former, the morphological characteristics of the soil profile are rarely taken into consideration. We shall now discuss the subjects briefly under two separate heads

(A) Several important soil surveys have been recently completed by the Madras Department of Agriculture. These comprise surveys of the deltaic areas of the districts of Tanjore (1914), Guntur (1915), Krishna, Godavari (1922) and of the Periyor tract of the Madura district (1923) and of Malabar (1928). The object of the surveys is to obtain some knowledge of the manurial requirements of the districts It does not pretend to determine the relative fertility of the soils In 1919, Wilsdon [8] stressed the importance of systematic soil surveys in India and described several main types of soils of the Punjab according to their physical characteristics Later in a publication on soils of the Punjab (1928) Lander and others [13] have summarised the up-to-date work on soils of the Punjab in which they have followed a geographical distribution of the province into five main divisions and have discussed the distinguishing characteristics of various soils Recently a survey of tea soils in the Kangra valley (1934) in the Punjab has been undertaken with a view to study the factors that are responsible for the poor growth of tea plants on the tea estates Similar surveys of the tea soils of Assam have been completed by the staff of the Indian Tea Association. In this connection the soils of the Mandaldai, Bishnath, Tezpur, North Lakhimpur (1922), South Sylhet, Dhunsiri, Nowgong (1924), North Sylhet, Golaghat Division (1925) and of the Terai (1926) have been examined In Assam, further work on soil survey of the Jorhat Sub-Division has been undertaken by the Agricultural Department, especial attention being paid to the soil acidity In Burma a chemical and physical examination of soils with a view to ascertaining fertilizer requirement has been completed for Akyab (1925), Pegu district (1931) and Mandalay canal area (1932). Later in 1935, a survey of the sugarcane soils has been taken up in which analysis of canes grown in different tracts has been used to determine the deficiencies or otherwise of soils Considerable amount of survey has also been carried out by Bihar and Orissa Department of Agriculture which covers representative areas of South Bhagalpur (1919 23), Santal Parganas (1920), Saran District (1922 26), South Monghyr (1923), Gaya and Patna districts (1925) Surveys of this kind have also been conducted in some parts of Central Provinces (1920), United Provinces (1928), Travancore (1928), Cochin (1930) and of Bengal (1933)

(B) Surveys of this type have been conducted in Madras, Mysore, Punjab, Sind and Bombay Soil surveys of the (1) Lower Bhavani, (2) Cauvery Mettur, (3) Tungabhadra and (4) Toludar were undertaken recently (1934) by the Madras Department of Agriculture of which the reports of the first two are already out It has been found that, although alkaline patches are noticeable in the soils of new areas under Cauvery Mettur Project, there will be no danger of alkalinity developing provided drainage facilities are given. The Bhavani soils are porous and it is likely that seepage may cause heavy transmission losses from the canals The soil survey of the Irwin canal in Mysore was completed in 1929 It covers an area of 70,000 acres and the analyses consist of mechanical, chemical and colloidal constituents of soils In the Punjab (1930) extensive soil surveys were carried out on behalf of the Irrigation Department, in connection with irrigation schemes for Haveli project, the Khiklee Pirmahal and Burala tracts of the Lower Chenab canals Further in connection with a [illegible] tube well irrigation, a soil and undergr[illegible] acres of Gurdaspur and Amritsar dist[illegible] survey indicated that the soil of an [illegible] irrigation and that the quality of the ur[illegible] tory for irrigation Similar surveys in L[illegible] are in progress In the Lloyd Barrage [illegible] survey has been made over an area of 1[illegible] Council of Agricultural Research have [illegible] soil survey according to modern methods for this area In the Bombay Presidency, a soil survey and soil classification on the depth and drainage basis has been recently (1932) completed by the Irrigation Research Division on the major canals of the Bombay Deccan.

(4) *The Genetic Classification.*—The genetic system of soil classification was developed primarily by two brilliant Russian pedologists Dokuchaiev (1879) and Sibirtzev (1898) who recognised the soil forming processes as bases for their soil classification. The "law of the development of soil types on the earth's surface under the influence of climate" was brought out by these scientists for the first time which was later put on a sounder foundation by Glinka[1] who introduced the modern concept of soil as an "independent, natural, historical body" whose complete expression is to be sought in a soil profile. This classification is stated in terms of maturity of profile development and the intensity of leaching by percolating water Although this system has a leaning towards climate as the most potent factor for soil formation it does not ignore parent material altogether. Thus Glinka wrote—"It should be remembered that we designate as soil the products of weathering which remain in the place where weathered It must carry the impression of all inner and outer forces which has taken part in its formation. In the morphology of the soil type the climatic conditions of the locality, the combined effect of moisture and heat the essential features of vegetation and the character of the parent rock all find expression Each of these factors constitutes a part of the soil forming processes "

The complete or partial genetic methods of soil survey have been recently employed in Bombay, the Punjab, Central Provinces, Madras and a few other places. In 1932, the Sugarcane Research Station at Padegaon (Bombay) started an extensive soil survey on the modern lines of the Deccan Canal soils with a view to study the suitability of soils for irrigation and cane growing The work on three major canals has been completed and eight soil types have been worked out which possess fundamentally different properties with regard to their morphological, physical, chemical, colloidal and biological characteristics Further work on their inter-genetic relationships, influences of the mineralogical composition of the parent material on soil types, phase difference and maturity of profile development etc, is in progress In the Central Provinces the clay fractions of some soils were submitted to fusion analysis. The results show the constancy of the silica : sesquioxide ratios of black soils derived from different rocks Similar work in Madras shows that the silica sesquioxides ratios of black soils are definitely higher than those of red soils occurring in the same tract In the Punjab Mackenzie Taylor and his associates have studied several soil profiles in the Hill areas of the Kulu Forest Division. Influence of forest growth on the processes of podsolisation has been studied in this connection. Work on genetic lines is in progress at Sabour in Bihar, Dacca in Bengal and in Hyderabad and several other places but as no informations are yet available in the departmental reports it is not possible to discuss them for the present. Finally we must acknowledge the very suggestive book in "The natural conditions of soil Formation in India" by Miss Z J Schokalsky who has given us some Russian outlook on Indian soils from the available data This compilation is likely to be very useful in our future work on soil surveys in India

(II) The Present Position of the Work

From a survey of the available literature on the subject the present position of the work on soil surveys in India may be summed up as follows —

(1) There is a great deal of material regarding the productivity of Indian soils obtainable from the settlement reports of various provinces which may serve as a guide in future planning of soil surveys

(2) The various records of the Geological Survey of India abound in literature on the broad relationships of soil formation with the parent materials which may serve as a useful foundation for further investigations on soil classification.

(3) The greatest amount of work has been done so far according to the physical and chemical methods of soil classification These surveys have given us already a mass of data on soils regarding their chemical and physical nature, their deficiencies or otherwise in plant food materials together with their field responses to manuring limits of alkali beyond which agricultural crops are unable to thrive well and the methods of their amelioration when totally unfit for crop growing There is, however a great lack of their co-ordination and a thorough understanding on the genetic relationships of various soils so that the results of one experimental farm cannot be applied to another with a great degree of certainty. It is almost impossible to forecast the probable behaviour of soils under irrigation on the basis of agricultural analyses of soils which does not take into account the soil profile as a unit of study. Similar lack of informations on the fundamental nature of an alkali soil may lead to futile efforts on the reclamation of such soils

(4) It is true that the genetic methods of soil survey have been recently under- ... experimental stations in India but the methods adopted ... needs to

measured, texture determined by mechanical analysis ... tests, structures properly described and photos and sketches supplied to explain them; colour should be measured by means of colour discs and colour charts so that there is hardly any loop hole for ambiguity and differences of opinion. Collection of monoliths for typical soil profiles should be kept in order to serve for future reference work. Finally the laboratory analyses should be such as to bring out the important soil characteristics as observed in the field so that the profiles are thoroughly defined chemically as well as physically once for all. Over and above this, the methods of analysis should be so chosen that the origin, nature and reactivities of the soils or in other words the genetic relationships for various soils are brought out in clear relief. For this purpose the Russian methods of soil analysis may be found very suitable.

(III) Future Plan of Work

In planning for a future programme of soil survey on an All-India basis, the wide ... the variations in geography, ... proportion should not be ... in detail. We shall limit our discussion ... extent

The climatic consideration has been stressed by the Russian soil scientists to the greatest extent. The cause is not very far to seek when we take into account the climate and geology of this great sub-continent. Let us examine to what extent it is applicable for Indian conditions. For this purpose we can take Lang's "rain factor" [13] i.e., the mean annual rainfall in mm divided by the mean annual temperature in °C as a first approximation for measuring the relative humidities (or leachings) of different places. The importance of this factor has been recently strengthened by the work of Crowther[14] who has shown that SiO_2/Al_2O_3 ratio in the weathered product is correlated negatively with rainfall and positively with temperature thus showing that the effective agent is not the amount of rain but the quantity of water circulating through the soil mass which is expressed by this ratio. It will be interesting to examine the "rain factors" for several well-known places of India as given below:—

Lang's Rain factor

(Range 0—20)

Jacobabad (3.9); Multan (6.6); Hyderabad Sind (7.0); Leh (16.9); Bellary (18.1).

(Range 21—40)

Coimbatore (21.6); Jaipur (24.0); Delhi (27.8); Poona (30.6); Hyderabad Deccan (30.9); Akola (31.0); Madura (31.7); Nellore (33.2); Indore (34.9); Benares (40.0).

(Range 41—60)

Bangalore (40.9); Nagpur (44.6); Madras (44.9); Patna (46.4); Belgaum (55.3); Cuttack (58.2); Jubbalpur (58.4).

(Range 61—80)

Calcutta (60.5); Trivandrum (62.1).

(Range 101—120)

Bombay (100.6); Calicut (114.1).

(Range 121—140).

Simla (125·2); Ootacamund (135·0).

(Ranges above 161).

Darjeeling (274·8); Cherrapunji (772·7)

To one who is well acquainted with the soils of the above places it would be quite evident that wide differences do exist among soils possessing similar 'rain factors'.

Coming to geological considerations we have instances in Madras Presidency where both Black and Red soils are to be found side by side under similar climatic condition derived from similar parent material, *viz.*, granite or gneiss. Here the minerological composition of the rock may be the deciding factor. The Black soils may be traced on various formations such as traps, granites, gneisses, lime-stone and shales in various places—a fact which strongly suggests its being of a climatic soil type. Laterites arise from the weathering of very different rocks (granite, diorite, etc.) and so also are the podsols, pedogenic processes in each case being governed by diametrically opposite forces in which the complexity of vegetation may mask the influences of climate and parent material to a great extent.

Lastly even when the parent material and climate are identical various soil types may be formed due to the characteristic pedogenic processes as influenced by topography and drainage. This is clearly exemplified by the recent identification of several soil types existing within a fairly small area in the canal zones of the Bombay Deccan. On the other hand solonetz-like soil formation has been traced in various places simply due to the natural influences of topography in this tract. The far reaching influences of high water tables in modifying the profile characteristics of soils are already too well known and need not be discussed here.

All these discussions leave no room for doubt as to the inadequacy of basing an all-India survey either on climatological or geological foundation alone. We are dealing with a very complex set of conditions in India when compared with either of Russia or Central Europe where climate or geology can serve the need of a soil classification in a straightforward manner. Among all these great diversities, however, we can at least find some unmistakable identity of the existence of a few broad groups of soils which have made their presence felt by their characteristic outward manifestations from time immemorial to the tillers of the soil, observant travellers, geologists and soil chemists ([17]), ([18]). Although very little is known regarding the inner and out processes which have led to their formation they are no less true than the Tshernosems, chestnut earths, Brown earths, Yellow or Red earths and Peat soils. These names were known before their genetic relationships were established. Hence it is logical to start a co-ordinated soil survey of India on the well-known groups of Indian soils on the basis of our present knowledge. These may be broadly grouped as under :—

I. *Desert soils group*

II. *Alkali soils group.*

III. *Black cotton soils and Regur*

IV. *Red soils group*

V. *Yellow soils group*

VI. *Forest and Hill soils group*

VII. *Laterites and Lateritic soils group*

VIII. *Meadow soils group (or ground water soils)*

The alluvial soils have not been put under a separate group for the obvious reason that they come under various groups already mentioned, *viz.*, I, II, VI and VIII.

A standardized genetic system of soil classification should be adopted all over India on the above groups and an attempt to evaluate the relative influences of the following factors on soil formation should be made : (1) Climate, (2) geology and parent material, (3) minerological composition of the rock, (4) vegetation, (5) topography, (6) drainage, (7) altitude and (8) ground water table. *Above all, the characteristic soil forming processes in each of these groups and how they are modified by the influences of the abovementioned factors are the necessary pre-requisite for a thorough understanding of these soils and for assigning their position in a World System of Soil Classification.*

If the basic principles of soil survey as laid down in this note are acceptable, the details of the future programme can be worked out as a matter of course.

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(ii). Broad groups of Indian soils—a summary.

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In a previous communication to this Board a review of soil survey work in India has been given and the present position discussed fully. The future line of work has also been indicated therein pointing out the inadequacy of either climate or geology as a satisfactory basis of soil classification and plea for planning a co-ordinated scheme of soil survey all over India on some broad distinctive groups of Indian soil has been put forth. These groups are provisionally fixed up as I Desert soils, II Alkali soils, III Black Cotton soils and Regur IV Red soils, V Yellow soils, VI Forest and Hill soils, VII Laterites and Lateritic soils and VIII Meadow or ground water soils. It is likely that further sub-divisions and modifications of these groupings will have to be made in the light of further researches on the modern lines. Although the available information is meagre yet an attempt to discuss its salient features and a suggestion on the probable line of future work would not be quite out of place on this occasion. To start with, I shall take two contrasting groups, *e.g.*, Groups I and VIII where pedogenic processes are diametrically opposite giving rise to two fundamentally different types of soils.

I Desert Soils Group

Desert soils of India occupy a large tract in Eastern Sind extending over the whole length of the province along the edge of the Indus alluvium, Rajputana and South Punjab, of which the Thar or Rajputana desert alone occupies an area of 40,000 square miles. The sands of the desert, according to Blanford are mainly derived from the old sea coast and their transport into the interior of the country is due to the south-west wind.

Analytical figures of some typical soils from Sind indicate the presence of high percentage of water soluble salts, high *p*H values, low loss on ignition figures, high residue insoluble in HCl but varying percentages of calcium oxides. Very little can be said from these results regarding the nature of desert weathering processes beyond the fact that the soils are rich in soluble products of soil weathering, poor in organic matter and that the *chemical* weathering probably has not advanced very far.

According to the Russian workers the characteristics of the desert weathering are :—

(1) An energetic mechanical disintegration of the rocks resulting in a fine grained material, which however, is blown away by winds, leaving a residue of coarse sand.

(2) The salts which under other climatic conditions disappear from the soil by leaching, accumulate in deserts and take part in chemical and mechanical weathering.

(3) The special feature of the morphology of the desert soils is their characteristic crusts. Hence these soils may be classified as desert soils with (i) lime crusts, (ii) gypsum crusts and (iii) brown protective crusts according to the nature of the soil forming processes the first indicating slightly more leached condition than the second or the third.

Analysis on the profile basis is essential in order to get a clearer idea regarding the true nature of the Indian desert soils on the basis of depth distribution of salts, combined with mechanical analysis of the soil profile and analysis of the weathering complex.

VIII Meadow or Ground Water Soils Group

The Meadow soils have been put into a separate category for the obvious reason that a fundamentally different set of soil forming processes are introduced in these soils by the nearness of the ground water table. They are characterised by the presence of a gley horizon which is of a reddish brown colour in the shape of streaks and mottlings of hydrated ferric oxide. These soils are essentially local in character and depend mainly on topographic situations which influence the movement of underground water. These are rich in organic matter and often show zones of calcium

carbonate and gypsum accumulation in the lower horizons and higher SiO_2/Al_2O_3 ratios of the clay complex Schokalsky has tentatively divided the Indian meadow soils into two groups (*a*) non leached in places carbonatic (with Kankar), (*b*) with traces of the process of podsolisation These soils are required to be worked out systematically in different parts of India

I shall now discuss a little more fully on three soil groups on which a fair amount of work on the modern genetic method has been completed. These are the groups II, III and VI mentioned already.

II. Alkali Soils

Quite a large amount of work is available on Indian alkali soils which are known under various names, viz., Reh, Kalar, Usar, Chopan, Karl etc, in different parts of India, but their morphology and soil forming processes are very little understood due to want of systematic investigations According to Sigmond three factors are responsible for the formation of alkali soils; namely, (1) The arid or semi arid climate itself, (2) An impervious sub soil or hard pan, (3) Temporary abundance of humidity in the soil, interspersed with dry periods To this we may add the influence of saline sub-soil water-table within easy reach of the soil profile Usually in the formation of alkali soils we may distinguish four stages of development: (1) Salinization, (2) alkalization, (3) Desalinization and (4) Solotization, of which the last phase is rarely met with in Indian soils due to the calcarrous nature of most of the alkali soils here

In the first stage soluble salts mainly of sodium, accumulate in the profile due either to impedence or nearness of saline sub-soil water The soil type formed is usually structureless

In the second stage, excess of sodium salts in solution replaces the exchange calcium of the soil The excess salts are, however, not removed from the soil mass thus greatly preventing the deflocculation of the sodium clay

In the third stage, excess salts are removed by leaching and a soil type with large percentage of exchange sodium without free salts on the surface layer is formed which shows definite laminated structure on the surface and badly dispersed condition when wet The first stage is according to Russian nomenclature "Solonchak" and the third stage is called "Selonetz" the intermediate being a transition stage where neither characteristics are pronounced

I had some opportunity of examining some Kalar soils of Sind which approximate very closely to the second stage described above

The profile was characterised by illuviation from the very beginning and hence the "A" horizon was totally absent The profile may be described as follows The top horizon B_1, 0 to 7 inches deep is a compact dark grey layer which overlies a yellowish, grey horizon B_2 10½ inches in thickness Below this there is a transitional layer B_3, 3 inches deep which is rather hard to scratch This is followed by hard pan layer B_4, very dark in colour with iron incrustations This B_1 layer can be further sub-divided into two distinct horizons, the upper one 2 inches in thickness which is granular in structure and the lower half 1½ inches which breaks up into clods and is often imbedded with fresh water shells Below this hard pan there is a glistening white sand layer B_5 1 ft and 11 inches deep, followed by a moist greyish black horizon B_6 which is heavier in texture than B_5.

The total salt distribution is of the Solonchak type (i e, 1·25 per cent. on the surface which falls off to a low value lower down to ·08 per cent. in the 24½″—36½″) yet the saturation with monovalent ions varies from 43—22 per cent in the whole profile.

There is slight eluviation of clay in the hard pan layer only. There are evidences of elaviation of silica and sesquioxides to a certain extent in the profile

Several solonetz like soils have been analysed at the Sugarcane Research Station, Padegaon, a typical one out of them can be described as under :—

A	0 — 24″	Uniform greyish black soil with pronounced structure; form very hard crust on drying.
B_1	24″— 58″	Intermediate zone, black mingled with brown.
B_2	58″—84″	Uniform reddish-brown material with zeolites. Exhibits shaly structure near the bottom.
B_3	84″—120″.	Reddish brown horizon mixed with white material.
B_4	120″—144″.	Same as above; white material predominating.

C horizon. It seems essential from theoretical considerations that the acid and unsaturated condition of the A horizon should prevail during the period of the profile development.

Whether this type of profile development takes place under acid humus conditions under high temperatures of the plains is a subject which requires careful investigation. Assam forest soils on low level are likely to afford considerable facilities in this direction. Under the second condition enumerated above a different type of profile results which may be described as follows :—A brown coloured soil with a thick A horizon with uniform distribution of humus which passes on imperceptibly into B horizon with a lower humus content but often enriched by clay. There is no characteristic illuviation of either humus or sesquioxides lower down the profile and the silica/sesquioxide ratios of the whole profile is practically constant throughout, with a change only in the 'C' horizon The base status of the soil is high and the reaction almost neutral and the soil formation usually takes place under deciduous forests where the surface soil receives constant supply of mineral ingredients from leaf-fall and earth worms. The structure of the soil is also well-developed crumbs and not singly grained like that of a podsol profile

Only work on forests soils on the profile basis we have got is that of, MacKenzie Taylor and his associates The soil types described by them are of high altitude (5,000 to 7,000 feet above sea level) under coniferous forests where the annual rainfall varies from 40 to 50 inches These soils are mostly of podsol or brown earth types Some of these podsols are, however, different from normal podsols in the sense that the surface horizon is highly base saturated and only very slightly acidic although eluviation of sesquioxides and humus can be definitely traced Such fundamental difference from normal podsol profiles is apparently paradoxical and suggests the view-point that the conditions prevalent now seem to have been super-imposed in a later period probably due to changes in the forest vegetation and that these soils are likely to undergo transformation into Brown Earths if these pedogenic conditions proceed uninterruptedly for ages

Forest soils require thorough investigations in the line Dr. Taylor has so successfully pursued and extended over low level and high level forests as well as under different conditions of soil base status

Groups IV, V, VII

Lastly the groups Red soils, yellow soils, laterites and lateritic soils can be conveniently discussed together as from various outward evidences close relationships of these soils are apparent Both Laterites and red soils possess vivid red colour although the former shows fundamentally different properties from the latter. Laterites are characterised by excess of sesquioxides, a vesicular or cellular structure with presence of concretions of iron oxide The soil which can be easily cut with a knife in the moist condition, assumes brick like hardness when dry These soils are usually well drained and porous They can be broadly divided into high level and low level laterites, the former being usually of a pale, gritty, thin and poor in nutritive substances and the latter of a finer texture and darker hues and contain a fair amount of humus A vast amount of literature is available from tropical countries like Africa, Java, Mauritius Cuba, etc., from which a fair amount of knowledge regarding the morphology, chemistry and origin of these soils can be had, which is likely to be useful in studying Indian Laterites. According to Robinson a laterite profile consists of 4 horizons (1) the parent rock succeeded by (2) an horizon in which the material is non lateritic and the immediate product of primary weathering, (3) the horizon of laterite proper, which passes into (4) an horizon characterised by ferruginous incrustations or concretions Two theories are at present in vogue regarding the origin of these soils One due to Campbell who considers laterites to result from changes which occur in the zones of permanent and intermittent saturation in the vicinity of a water table The second theory is due to Glinka who assumes that the alkaline character of the soil leaching removes silica from silicate material leaving an horizon rich in sesquioxides Whether it is due to eluviation of SiO_2 or illuviation of sesquioxides in the surface horizon it is now generally accepted that the principal climatic circumstances are high temperature and the alternation of wet seasons with intense drought. Martin and Doyne have sub-divided these soils into Laterites having SiO_2/Al_2O_3 ratios of less than 1 33 and Lateritic soils possessing ratios between 2·0 to 1 33

Soluble salts show a solonetz type of distribution, *i.e.*, starting with a low value (about ·2 per cent) and increasing gradually with depth reaching its maximum concentration (2·2 per cent) in the B_2 horizon after which it falls off with depth. The pH value is highest at the surface A horizon (8·9) and lowest in the B_2 horizon. Calcium carbonate exhibits zones of accumulation in the B_3 and again in B_4. The 'A' horizon shows sodium saturation to the extent of 15·23 per cent, which is probably responsible for the compact nature of this horizon. There is eluviation of clay as well as of silica and iron in the profile.

The Rakkar and Thur types of alkali soils as described by the Punjab Irrigation Research Institute seem to fall under the third (*i.e.*, Solonetz) and first (*i.e.*, Solonchak) category of alkali soils. Without further work the genetics of the Indian alkali soils cannot be thoroughly established

III. *Black Cotton Soils and Regur.*

From an examination of a number of profiles under a drier climatic condition (*i.e.*, with rainfalls of 18″—28″ annually) of the Black Cotton soils area of the Bombay Deccan it has been possible to distinguish eight distinct soil types. Basis of classification has been the morphology of the profiles and characteristics of the soil forming processes [In the first stage of soil classification 'zones of accumulation of soluble salts' have been taken to characterise them into two broad groups. In the second and third stages the colour profile and eluviation of clay have been used for differentiation and in the final stage the exchangeable bases and their distribution have been found useful in confirming the morphology of the soil types.]

These soils come under the Tschernosem soil group due to the fact that they are all highly base saturated (mainly with calcium) and normally possess well defined granular or crumb structure although some of the soils possess a brown colour like that of a Chestnut earth. Some of these soils, however, grade toward Solonetz like soil (alkali soil with structure) when the percentage sodium in the exchange complex increases considerably on the surface horizon due to either topographic situation or impedence of the underlying parent material. Fundamental differences are, however, (i) low humus contents of these soils, (ii) calcareous nature of the surface soils, (iii) absence of zones of accumulation of $CaCO_3$ in certain soils due to shallower depths and presence of a zone of accumulation of soluble salts in addition to $CaCO_3$ in deeper profiles, (iv) influences of a tropical climate is felt in the eluviation of clay, SiO_2, Al_2O_3 and Fe_2O_3 in certain profiles From all these pedogenic considerations it would be safe to class these soils tentatively in a separate group altogether and term them as Immature Tropical Tschernosems, immature because the leaching processes have not proceeded as far as in the proper Tschernosems and Tropical because of the evidences of break down of the silicate complex in certain soils

Until further evidences are forthcoming on the characteristics of the soil forming processes under definitely higher rainfall conditions it would not be possible to generalise on the genetic nature of this very important broad group of Indian soil.

VI. Forest and Hill Soils Group.

I shall now discuss about the group VI—the Forest and Hill soils These soils have been provisionally placed in one group because the soil forming processes in these soils are mainly governed by the characteristic decomposition of the organic matter derived from forest growths It is not necessary that all these soils should be on higher altitude as forest growth is possible on low lying areas where the precipitation is sufficient to ensure their growth The problems under this head are very complex as higher altitude introduces fundamentally different soil climates from the forest soils on the plains of India where the temperature may be considerably higher. Two conditions may, however, be broadly distinguished: (1) soils formed under acid condition with the presence of acid humus and low base status, (2) soils formed under slightly acidic or neutral condition with high base status. Soils under (1) and probably under lower temperature conditions as obtains on hills and mountains of India, podsol type of soil formation is likely to take place with the following characteristics:—

The formation of a peaty acid layer A_0 followed by a bleached horizon A_1 depleted of humus and sesquioxides; this in succession passes into brownish coloured B horizons with characteristic illuviation of sesquioxides and humus or sesquioxides alone. Below this we have the parent material which can be designated as the

C horizon. It seems essential from theoretical considerations that the acid and unsaturated condition of the A horizon should prevail during the period of the profile development.

Whether this type of profile development takes place under acid humus conditions under high temperatures of the plains is a subject which requires careful investigation. Assam forest soils on low level are likely to afford considerable facilities in this direction. Under the second condition enumerated above a different type of profile results which may be described as follows :—A brown coloured soil with a thick A horizon with uniform distribution of humus which passes on imperceptibly into B horizon with a lower humus content but often enriched by clay. There is no characteristic illoviation of either humus or sesquioxides lower down the profile and the silica/sesquioxide ratios of the whole profile is practically constant throughout, with a change only in the 'C' horizon. The base status of the soil is high and the reaction almost neutral and the soil formation usually takes place under deciduous forests where the surface soil receives constant supply of mineral ingredients from leaf-fall and earth worms. The structure of the soil is also well-developed crumbs and not singly grained like that of a podsol profile.

Only work on forests soils on the profile basis we have got is that of, MacKenzie Taylor and his associates. The soil types described by them are of high altitude (5,000 to 7,000 feet above sea level) under coniferous forests where the annual rainfall varies from 40 to 50 inches. These soils are mostly of podsol or brown earth types. Some of these podsols are, however, different from normal podsols in the sense that the surface horizon is highly base saturated and only very slightly acidic although eluviation of sesquioxides and humus can be definitely traced. Such fundamental difference from normal podsol profiles is apparently paradoxical and suggests the view-point that the conditions prevalent now seem to have been super-imposed in a later period probably due to changes in the forest vegetation and that these soils are likely to undergo transformation into Brown Earths if these pedogenic conditions proceed uninterruptedly for ages.

Forest soils require thorough investigations in the line Dr. Taylor has so successfully pursued and extended over low level and high level forests as well as under different conditions of soil base status.

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In "Oldham's Geology of India" the red soils of India are described thus—"The somewhat ferruginous soils common on the surface of many Indian rocks and especially of the metamorphic formations would probably never have attracted much attention but for the contrast they present in appearance to the black soil. The commonest form of red soils is a sandy clay, coloured by iron peroxide and either derived from the rock *in situ* or from the same products of decomposition washed to a lower elevation by rain The term is, however, used in a very vague sense, apparently to distinguish such soils as are not black, and hence many alluvial soils may be included under the general term" Analytical figures of some red soils of Madras indicate that the amount of lime is small, the magnesia is not high and the phosphoric acid uniformly low Fe_2O_3 and Al_2O_3 are also fairly low and are comparable with the black soils It has been shown in Madras, however, that under identical climatic and geological conditions both black and red soils are found to occur although the SiO_2/Al_2O_3 ratio of the latter is decidedly lower than that of the former. It has been suggested therefore that this may be due to the differences in the minerological composition of the parent material These red soils are usually found under dry steppe type of vegetation Red soils have also been found under forest vegetation which probably differ to a certain extent from the red soils of Madras just described I have come across vast stretches of such soils in the North Kanara under deciduous forests where the surface horizon seems to be of a darker red colour which passes on to a lighter red coloured horizon probably low in humus, effervescence with dil acid often taking place on the surface horizon. That in the formation of these soils high temperatures in summer coupled with heavy monsoon showers take an important role, can be easily inferred but what part the organic matter plays in the soil formation cannot be gauged without complete analysis of some typical profiles of this area That they are closely related to laterites and yellow soils can be seen from their occurrence in close proximity in the same area. An almost laterite like profile was examined by me near about Siddapur in North Kanara which showed a red soil with vesicular structure possessing concretions of iron oxide which passes into a yellow, loose and friable layer overlying parent material of gneissic rock Side by side, yellow and red soils can be also seen on some patches of forest soils recently cleared up Very little is at present known about these yellow soils The yellow colour is probably due to a higher degree of hydration of the ferric oxide in these soils than in the red soils It seems almost like a transition group between the red soils and the brown forest soils from the point of view of structure That the forest shade plays an important part in the way of lesser evaporation and lower temperature it is not difficult to guess from their situations Investigations on these soils are likely to shed considerable light on the intergenetic relationships of some of these broad groups of Indian soils.

In conclusion I would suggest that a co-ordinated research may be undertaken on the different soil groups that I have outlined above under the guidance of a central body like *Soil Bureau* with the help of soil workers in different provinces of India.

APPENDIX IV, B.

Soil surveys as an important item of soil research work.

(DR. P. E. LANDER, I.A.S., *Agricultural Chemist to Government, Punjab, Lyallpur.*)

The importance of undertaking systematic soil surveys as an important factor in any scheme of agricultural improvement is fully appreciated and subject has been discussed at some length in the first meeting of the Crops and Soil Wing of the Board of Agriculture and Animal Husbandry in India, held at Delhi in 1935. What is now required is that definite shape be given to the suggestions made and tentative conclusions already arrived at. Each Province, keeping in view its particular soil condition should take in hand systematic and co-ordinated soil surveys beginning with a small area as a nucleus. In this brief note I would like again to stress the utility of this work, taking certain aspects of the Punjab soils as illustrating the conditions where results obtained from an investigation of this type can be usefully employed.

One of the major soil problems with which this province is confronted at present, and one which is likely to become more acute in future is that of "Kalar". There is still some divergence of opinion among "experts", as to the precise factors which operate in the long run to produce "Kalar", and as to the immediate predisposing causes.

If we go back in history to the time when the Canal system was started in the Punjab, the problems of Kalar and Water-logging did not exist, certainly not to an extent remotely approaching that seen to-day.

At the time that the Canals were built the problem of drainage was overlooked. When new lands were taken under irrigation no one bothered to carry out chemical soil surveys of these lands—they were good fertile lands for the major part, and that was sufficient. To-day many of these lands have deteriorated and gone out of cultivation. It is highly probable that if Government in the early days had been asked to provide an efficient chemical staff to carry out surveys and continue them, it would have demurred against an apparently unnecessary expenditure. It is equally possible that if an Agricultural Chemist in those days had occupied himself with soil investigations of the nature under consideration now, he might have been regarded as not justifying his existence as his work could not be shown to be bringing any increase in wealth to the zamindar. This at first sight is possibly true.

It is equally possible however if an organisation had existed from the first to survey and keep records and a check on changes which were occurring in the soils of this province, then while no spectacular discovery might have been discovered which would bring wealth more rapidly to the zamindar yet a mass of information would have been accumulated about our soils which if properly taken heed of might have saved the province great loss from soil deterioration. The position in regard to Kalar and Water-logging as it exists in the Punjab to-day is the result of what has been done, or left undone in the past. If systematic work had been done on soil surveys in years gone by, a check might have been kept on the process of deterioration of many soils which have to-day gone out of cultivation and possibly much loss might have been averted.

There are to-day large areas of good soils producing excellent crops, which can hardly be increased, even by the application of artificial manures. There is evidence available, however, that this happy condition may not always hold good, and that in 6, 10, 20, 30, 40 years time, or some date in the future, much of this land will have deteriorated or even gone out of cultivation altogether.

I have submitted recently some suggestions as to the directions in which we might turn our attention in soil work. I made a tentative suggestion that the Agricultural Department should systematically survey, with such staff as is available, certain definite areas.

It is gratifying to note that my suggestion has been accepted by the Punjab Government and sanction has been accorded for beginning systematic soil surveys on a small scale. We have decided to make a start with the Lyallpur District, making the Lyallpur Agricultural Station as centre from which our soil surveys of the district would radiate in all directions. The reasons for selecting Lyallpur are that this is one of the richest and most fertile areas of the province, and that it is an area where the water table is rising year by year, and that there are possibilities that unless proper measures are taken at the proper time in the future, much of the soil of the Lyallpur area will have deteriorated.

APPENDIX IV, C.

Monoliths of typical Indian soils.

(DR. B. K. MUKERJI, *Agricultural Chemist to Government, United Provinces.*)

In the first meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India, held in February 1935, it was suggested that an all-India soil survey based on Agricultural needs was desirable and would be of considerable value. Accordingly, a preliminary survey of the more representative soils of the United Provinces has recently been taken up. This includes the preparation of soil monoliths from three different soils.

The monoliths which have been taken in each case to a depth of six feet of the profile, form an interesting study regarding the formation and composition of the surface and sub-soils. The horizons in the case of the *usar* soil profile are not very sharply defined, although a thick layer of *kankar* occurs at a depth of about 3½ feet. The division of the profile into different horizons is well marked in the other two cases.

Such monoliths are likely to prove extremely valuable for studying the composition of the soil at different depths of the profile. In these the natural soil formation is truly represented and they can be maintained permanently for reference in the future. It is, therefore, suggested that monoliths of the more important soil types be prepared in all the Provinces so as to be available to different soil workers in India.

number of varieties is necessary to suit the very varied conditions obtaining even in parts of the same province The list of improved varieties, evolved mostly by single plant selection, in different parts of India is therefore a lengthy one including such well known strains as G. E. B. 24 in Madras, Indrasail in Bengal, Dahia in Bihar, the Kolamba strains in Bombay, etc

Intensive work is still in progress, and hybridisation is being increasingly resorted to. Well known American varieties such as Blue Rose have been used in crosses in Bengal, Burma, etc., to improve the quality of the grain. An interesting problem which has been taken up in the United Provinces has been the breeding of a variety resistant to the ravages of the rice fly (*Leptocorisa varicornis*), by crossing high quality and heavy-yielding rice varieties with the coarse, early-ripening "Sathi" rices, and thereby associating the desirable qualities of the former with the protective sheath of the latter By similar methods, an effort has been made in the Central Provinces to eradicate the ubiquitous wild rice (*karga*) The problem of the wild rice is that it cannot be distinguished from most of the commercial varieties, in the earlier stages of the crop In order to discriminate the commercial varieties from the wild rice, the former are being "coloured" by hybridisation with a coloured variety.

Cotton.—As a cotton producing country India ranks second in importance only to the United States of America In many of the Indian Provinces and States cotton occupies by far the most important place among the money crops It is not surprising therefore that the improvement of this crop has received a prominent place in the programmes of plants breeders The earliest work on the systematic improvement of this crop in India was that of Gammie who was Economic Botanist to the Government of Bombay and later held the post (now abolished) of Imperial Cotton Specialist Fyson in Madras and Leake in the United Provinces started selection and hybridisation work as early as 1904 and improvement work on cotton through breeding has progressed steadily in most of the cotton growing Provinces and States throughout India A definite advance in this direction was made in 1921 when the Indian Central Cotton Committee was constituted as an advisory body and later incorporated under the Indian Cotton Cess Act of 1923 and provided with funds of its own The Committee has carried out extensive work on the improvement and development of cotton growing, marketing, and the manufacture of cotton in India The establishment, in 1924, of the Institute of Plant Industry, at Indore, for fundamental research on cotton, and of the Technological Laboratory at Matunga, has greatly facilitated the work of cotton breeders

The practice of importing inferior cotton for purposes of adulteration into areas growing superior cotton was once so rampant that the premia previously obtained for the cotton of certain tracts slowly disappeared The Cotton Transport Act was accordingly passed by the Government of India to check this evil · the main object of this Act is to create and maintain islands of superior types of cotton in tracts where soil and climate are favourable for the production of such types by preventing the importation of inferior cotton into such areas The question of the types of cotton to be grown in such islands is therefore of great importance

The cultivated Asiatic cottons in India (according to Hutchinson and Ghose, 1937) belong to the species *Gossypium arboreum* L (vars *typicum*, *neglectum* and *cernuum*) and *G herbaceum* L (vars *typicum*, *frutescens* and *africanum*) and the introduced American cotton belong chiefly to the species *G hirsutum* This American species has been successfully cultivated in the Punjab, Sind and Madras The outstanding strains of this cotton are the Punjab American 4F, 43F, 289F, Sind American (Sind Sudhar) 289 F, Sind American N T and Cambodia of Madras. The outstanding Asiatic cotton varieties are Sind *desi* and Sind N R in Sind, Punjab (*desi*) mollisoni cotton with a variable mixture of *indicum*, *neglectum* and *sanguineum* in the Punjab, Jayawant, Gadag No 1, Banilla, B D 8, 1027 A. L F., Kumpta and Dharwar 1 in the Bombay cotton area; Verom 262, Late Verum; Verum 434, Verum 433 and Bani in the Central Provinces and Berar, Malvi 1 and Malvi 9 in Central India; Mungari, Jowari, Hagari 1 (H—1), Nandyal—14 and the Cocanadas in Madras, Abgarh A 19 and C 520 in the United Provinces, and Comilla in Bengal.

Sugarcane.—There are two great sugarcane tracts in India: a northern sub tropical tract represented by the Gangetic Plain and a southern tropical region, *i e*, the Peninsula The latter is suitable for growing thick canes but in the former were found only the thin, hardly, fibrous, indigenous varieties, generally not suitable for sugar production. The bulk of the sugarcane tract however, lies in the sub tropics and the development of the sugar industry in India depended on the improvement

APPENDIX V. A.

Notes on Subject IV (A review of plant breeding in India with suggestions for the future).

(NOTE BY DR. B. P. PAL, *Imperial Economic Botanist, Imperial Agricultural Research Institute, New Delhi.*)

PAST HISTORY OF PLANT BREEDING IN INDIA.

Plant breeding is a branch of agricultural science which has been up to now perhaps more art than science. It is however steadily raising itself on a scientific basis by the help of discoveries in genetics and cognate sciences. The past history of plant breeding throughout the world discloses a story of absorbing interest. In the present note however we are concerned only with its past history in India.

The beginnings of plant breeding in India are shrouded in obscurity. While in India, as elsewhere in the world, a certain amount of progress was made by selecting outstanding plants in the field for seed purposes, and by other simple means, it is unlikely that any substantial progress took place until after the re-discovery of Mendel's laws of inheritance in 1900 when in the words of Hunter and Leake (1933), "For the first time the plant breeder was offered an opportunity of producing new plants better suited to the many and very varied requirements of agriculture and commerce in an orderly manner."

The foundations of modern plant breeding in India were laid by such pioneers as the Howards, Barber, Leake, Gammie, etc. A brief summary of the work done in the case of a few of the more important crops is given in the following pages.

Wheat.—The improved varieties of wheat produced in India are now famous throughout the world. Not only are they better yielders than the older varieties, but many of them also are of excellent grain quality. The foundations of the wheat breeding work of the Imperial Agricultural Research Institute were well laid by the Howards who, a recent review of wheat breeding by the United States Department of Agriculture (1936) states, "have long been prominent among India's wheat breeders, and indeed among the wheat breeders of the world". Pusa 4 and Pusa 12, selected by the Howards, may be said to be household words in large tracts in India; Pusa 52, Pusa 80-5, and Pusa 101 produced by hybridisation have also proved very successful. Among the more recent varieties issued by the Agricultural Research Institute, Pusa 111, a mutant from Pusa 4, has been outstanding for its grain quality, Pusa 114 selected from a natural cross in Federation has been popular in the Barrage area in Sind on account of its rust-resistance, Pusa 120 is highly rust-resistant, particularly to yellow rust, and Pusa 165 is a good, all round early wheat. The two last mentioned varieties have been derived from crosses between the Australian variety, Federation, and Pusa 52 and Pusa 4, respectively.

Notable successes have also been achieved in the wheat growing provinces. The Punjab variety, 8A, has been popular in the Punjab and is now grown on an area of about 2½ million acres. More recently several strains of hybrid origin, *e.g.*, C. 518, C. 591, etc. have been produced which are superior to and are likely to replace 8A. In the United Provinces the variety, Cawnpore 13, selected by the United Provinces Department of Agriculture is reported to be doing well.

In Peninsular India, the position is rather different to that in Northern India, and durum, turgidum and emmer wheats are more extensively grown. In the Bombay Presidency several promising strains have been bred and are now under distribution to cultivators. In the Central Provinces also improved varieties have been bred.

In Sind in addition to Pusa 114 and Punjab 8-A, the selections C. Ph. 47, A. T. 38 and H. S. W. 111 made by the local department of agriculture are reported to be popular.

Rice.—Rice occupies the largest area under any one crop in India and its important place in Indian agriculture is reflected in the very considerable attention which has been paid to its improvement in all parts of India. The research on rice is to a large extent financed by the Imperial Council of Agricultural Research. Owing to the extreme ecologic specialization of the rice plant, a variety which does well in one district may not succeed in the adjoining district: for this reason a large

number of varieties is necessary to suit the very varied conditions obtaining even in parts of the same province The list of improved varieties, evolved mostly by single plant selection, in different parts of India is therefore a lengthy one including such well known strains as G. E. B. 24 in Madras, Indrasail in Bengal, Dahia in Bihar, the Kolamba strains in Bombay, etc.

Intensive work is still in progress, and hybridisation is being increasingly resorted to. Well-known American varieties such as Blue Rose have been used in crosses in Bengal, Burma, etc, to improve the quality of the grain. An interesting problem which has been taken up in the United Provinces has been the breeding of a variety resistant to the ravages of the rice fly (*Leptocorisa varicornis*), by crossing high-quality and heavy-yielding rice varieties with the coarse, early-ripening "Sathi" rices, and thereby associating the desirable qualities of the former with the protective sheath of the latter By similar methods, an effort has been made in the Central Provinces to eradicate the ubiquitous wild rice (*Larga*) The problem of the wild rice is that it cannot be distinguished from most of the commercial varieties, in the earlier stages of the crop In order to discriminate the commercial varieties from the wild rice, the former are being "coloured" by hybridisation with a coloured variety.

Cotton.—As a cotton producing country India ranks second in importance only to the United States of America In many of the Indian Provinces and States cotton occupies by far the most important place among the money crops It is not surprising therefore that the improvement of this crop has received a prominent place in the programmes of plants breeders The earliest work on the systematic improvement of this crop in India was that of Gammie who was Economic Botanist to the Government of Bombay and later held the post (now abolished) of Imperial Cotton Specialist Fyson in Madras and Leake in the United Provinces started selection and hybridization work as early as 1904 and improvement work on cotton through breeding has progressed steadily in most of the cotton growing Provinces and States throughout India A definite advance in this direction was made in 1921 when the Indian Central Cotton Committee was constituted as an advisory body and later incorporated under the Indian Cotton Cess Act of 1923 and provided with funds of its own The Committee has carried out extensive work on the improvement and development of cotton growing, marketing, and the manufacture of cotton in India The establishment, in 1924, of the Institute of Plant Industry, at Indore, for fundamental research on cotton, and of the Technological Laboratory at Matunga, has greatly facilitated the work of cotton breeders

The practice of importing inferior cotton for purposes of adulteration into areas growing superior cotton was once so rampant that the premia previously obtained for the cotton of certain tracts slowly disappeared The Cotton Transport Act was accordingly passed by the Government of India to check this evil the main object of this Act is to create and maintain islands of superior types of cotton in tracts where soil and climate are favourable for the production of such types by preventing the importation of inferior cotton into such areas The question of the types of cotton to be grown in such islands is therefore of great importance

The cultivated Asiatic cottons in India (according to Hutchinson and Ghose 1937) belong to the species *Gossypium arboreum* L. (vars *typicum*, *neglectum* and *cernuum*) and *G herbaceum* L. (vars *typicum* *frutescens* and *africanum*) and the introduced American cotton belong chiefly to the species *G hirsutum* This American species has been successfully cultivated in the Punjab Sind and Madras The outstanding strains of this cotton are the Punjab American 4F, 43F, 277F, Sind American (Sind Sudhar) 289 F Sind American N T and Cambodia of Madras The outstanding Asiatic cotton varieties are Sind *desi* and Sind N R in Sind, Punjab (*desi*) mollisoni cotton with a variable mixture of *indicum*, *neglectum* and *sanguineum* in the Punjab, Jayawant, Gadag No 1, Banilla, B D 8, 1027 A. L. F, Kumpta and Dharwar 1 in the Bombay cotton area; Verum 262, Late Verum; Verum 434, Verum 433 and Bani in the Central Provinces and Berar, Malvi I and Malvi 9 in Central India; Mungari, Jowari, Hagari 1 (H—1), Nandyal—14 and the Cocanadas in Madras, Aligarh A 19 and C 520 in the United Provinces, and Comilla in Bengal.

Sugarcane.—There are two great sugarcane tracts in India: a northern sub-tropical tract represented by the Gangetic Plain and a southern tropical region, i.e., the Peninsula The latter is suitable for growing thick canes but in the former were found only the thin hardy, fibrous, indigenous varieties, generally not suitable for sugar production The bulk of the sugarcane tract however, lies in the sub-tropics and the development of the sugar industry in India depended on the improvement

of the North Indian canes. What was required was a type of cane adapted to the short season of the sugar tract, with a high sucrose content and adequate yield. As however the sugarcane does not flower freely in the North, a station for the improvement of canes was established at Coimbatore in 1912-13. Previously some work on sugarcane had been done, notably at Manjeri at Bombay and Samalkota in Madras but substantial work commenced with the establishment of the Coimbatore Station. The work of the Coimbatore Station is internationally known and countries outside India have been able to derive benefit from the breeding work done there.

The work of breeding canes suitable for the varied conditions of soil and climate obtaining in various parts of India has involved the collection and acclimatization of as many species and varieties as possible, the study of their flowering habits with the object of inducing as many of them as possible to flower, the raising of large numbers of seedlings and the selection from the latter of clones characterised by high percentage of sucrose in the juice, great vigour and good habit. For North Indian conditions where thick canes do not thrive, crosses had to be made between the hardy thin canes and thick tropical canes. This presented many difficulties because of the difficulty of emasculation, sterility of certain varieties, etc. These were however overcome and from the crosses have been derived many of the now famous Coimbatore varieties.

Even in the early days of the work, crossing with the wild *S. spontaneum* was done in order to introduce into the noble canes, the greater vigour and hardiness of the former. This resulted in the production of several useful strains. Inter-varietal, interspecific and even intergeneric hybridization has played a prominent part in the production of new varieties at the Station.

The intergeneric crosses with sorghum held out the fascinating prospect of producing early maturing types with a high sucrose content but so far this hope has not yet been realized. This has however not deterred further attempts at inter-specific and intergeneric hybridisation as it is believed that success in sugarcane breeding depends largely on the extent of variation which can be secured in the seedlings raised. Hybridisation studies now include *S. arundinaceum*, *S. Robustum*, *Sorghum*, *Imperata*, *Erianthus*, etc. Very recently a cross between sugarcane and a bamboo (*Bambusa arundinacea*) has been successfully made.

The varieties of sugarcane are highly heterozygous and latterly inbreeding as a method of producing new desirable types has been tried with success. Several canes, *e.g.*, 348, 321, 395, 397, 317-19, have been produced by this means.

Over the greater portion of the sugarcane area in India the term 'improved canes' has become synonymous with Coimbatore canes.

Among the many canes distributed may be mentioned Co 313, 341, 370, 213, 244 and 290 in the United Provinces, Co 213, 313, 331, 299 in Bihar, Co 285, 233, 213, 220, 281 and 205 in the Punjab, Co 213, 243, 281 in Madras, Co 213 in Bengal. The newer canes often include some superior to the ones that had preceded them. Thus Co. 205 has been replaced by Co 235 and Co 285 in its turn is being supplanted by other canes which have proved superior to it. The "universal" cane Co 213 is losing ground against newer canes such as Co 290, 312, 313 and 421.

Recently it has been shown that sugarcane can be induced to flower and set seeds in certain tracts in Northern India and breeding work is now carried on side by side with the testing work, at a few stations.

In the United Provinces a systematic study of the crop has been completed and strains possessing rust-resistance have been evolved. Work on combining rust resistance with other desirable characters is in progress and tests have shown that some of the crossbred strains are better and more disease-resistant than the best local selections. Strain No 1150 is an outstanding. one.

In the Central Provinces, the selection E B. 3 is the best for Berar, Nagpur and Chhattisgarh divisions This strain in addition to producing a bold seed, has a well-developed and deep-seated root-system, so that it withstands drought, while its early maturity enables it to escape rust. Crosses have been made between the local linseeds and rust and wilt resistant imported flaxes

In Bihar the selection, Sabour Type 6, is wilt-resistant. Experiments are in progress to unite this character with the high yield of the Pusa strains Some of the locally selected types, in Bengal, have been found to be more suitable than the Pusa strains which are not early enough to suit Bengal conditions. In the Punjab, 57 pure lines have been isolated Work on linseed breeding was commenced comparatively recently in the Bombay Presidency. The local varieties were reported to be superior to the types from other Provinces. The latter however will be employed in breeding for introducing light seed colour into the former

Tobacco—This is an important money crop in many parts of India. Increasing attention has been paid to the production of tobacco suitable for cigarette manufacture As the indigenous varieties were found to be unsuitable for high grade cigarette manufacture, foreign varieties were introduced and acclimatized. Among the most important of these are Harrison's Special and Adcock At Pusa two strains (H. 142 and H. 177), suitable for high grade cigarette manufacture have been produced by hybridising the Indian variety, Pusa Type 28, with Adcock.

Among other important varieties bred in India may be mentioned:

At Pusa · Type 28 (chewing tobacco)
Rustica No 18 (Hookah tobacco)

Bombay. Gandiu No 6, Pilhu No 28.

Punjab: No 12 (hookah), No 57 (cigarette).

Bengal: Bengi
Motihari (hookah)

Other Crops—Breeding work with a large number of other crops has also been done including barley, oats, maize, millets, pulses, groundnut, sesamum, jute, hibiscus, sunn hemp, potatoes, etc, but it is not possible to refer to this in such a brief summary. Enough examples have however been given to show that the plant breeders in India have not been idle and that many valuable strains of crops have resulted from their labours

The Present Position, and Suggestions for the Future

As has been described in the preceding section, there has been considerable progress in plant breeding, and introduction and acclimatization of varieties, mass selection, single plant selection and hybridization have all been employed with varying degrees of success At the present time all phases of plant breeding may be said to have been intensified This is in no small measure due to the activities of the Imperial Council of Agricultural Research which has provided the funds for the organization and carrying out of schemes on a large number of problems relating to agricultural research There is evidence that the Indian plant breeders are keeping in touch with modern developments and the methods in use in the most progressive countries abroad are being also adopted in this country The use of X rays to induce mutations has been employed, for example, at Coimbatore (rice) and in Mysore (sugarcane) The use of distant or wide crosses has already been illustrated in the account of the sugarcane breeding work It is not so long ago that the belief existed that wide crosses were of academic interest only and not likely to yield results of economic value Recently, however, improvements in the technique of hybridization together with the discovery that doubling of the chromosome complement may render sterile hybrids fertile, has stimulated interest in such crosses In the U S S R great things are expected from the crosses between wheat and species of the perennial grass, *Agropyrum* It is too early at this stage to attempt to predict the economic value of the bamboo-sugarcane cross achieved at the Cane breeding station at Coimbatore but it holds out interesting possibilities

The process of vernalization about which so much is heard now-a-days has been applied to Indian crops at Pusa and elsewhere. The results obtained thus far, however, have been rather disappointing

Breeding for disease resistance, now recognised to be one of the most fruitful lines of research, is increasingly appearing in the programmes of Indian plant breeders. One of the best known examples of this is the scheme for breeding rust-resistant wheats which was commenced about two years ago and has for its object the production of strains combining high rust resistance to the three rusts occurring in India with other commercially desirable qualities.

When so much work is being done at a large number of centres there is the danger of undesirable over-lapping and duplication of work. It is in this connection that one may venture to make a few suggestions regarding future policy. Experience has shown that crops may be broadly divided into two groups: those with very limited adaptability, *e.g.*, rice and those with very considerable adaptability, *e.g.*, wheat. There is of course no hard and fast line between them Rice varieties are often of such limited adaptability that a variety which flourishes in one district may prove to be a failure in an adjacent district. In the case of wheat, however, we have varieties such as Pusa 4 which can be successfully grown in many different parts of India and is even cultivated in countries abroad It would probably be desirable in the case of crops like wheat to restrict the breeding work to two or three main stations. The varieties produced at these main stations could then be tested at a number of testing out centres distributed over the most important areas where that crop is grown. Such restriction of breeding stations would not only result in greater economy but it would enable breeding to be done for large tracts and thereby ensure the greater uniformity of product which is so important from the marketing point of view.

Problems such as vernalization and some of the more difficult problems of producing disease-resistant varieties are also probably best handled at one or two central research stations where extensive collections of crops can be maintained and where necessary library and laboratory facilities can be provided on the scale necessary for the highest standard of work The central station should also carry out research into the methods of increasing genetic variability by means of X-rays, exposure to heat, cold, etc., cytology of crop-plants, etc.

The importance of maintaining crop collections has been recognised and the subject was considered last year and again, early this year, by committees of the Imperial Council of Agricultural Research Fairly large collections of indigenous crop varieties are already maintained by the Imperial Agricultural Research Institute and by some of the Provincial centres of agricultural research The question of registration of varieties (such as has been approved by the Wheat Committee in the case of wheat) is also one of importance and one which requires attention.

The first meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India which was held in 1935 discussed the question of establishing a Bureau of Plant Introduction in a predominantly agricultural country such as India. Such a central Bureau would undoubtedly be of immense value for the purpose of introducing and testing, in co-operation with the Provinces and States, new crop plants and varieties from other countries The Board approved of the idea of establishing a Bureau the functions of which would be (*a*) to facilitate the controlled imports of new species and varieties of crop plants and other plants of economic importance; (*b*) to assist explorations as and when required in India and other countries; and (*c*) to investigate methods of securing control of plant introduction. The Imperial Council of Agricultural Research was invited to formulate a scheme giving effect to these proposals This scheme will be awaited with much interest by breeders and geneticists

APPENDIX V, B.

(NOTE BY RAO SAHIB K. I. THADANI, *Director of Agriculture, Sind.*)

Introduction.—Systematic plant breeding studies on modern lines based on pure line theory in crop plants of Sind and breeding of improved types did not commence in Sind earlier than 1916 when a Special Officer was appointed for this work. Till then mass selection of well developed ear heads of grain crops and fully opened bolls of the most vigorous plants was the sum and substance of all plant breeding work. The mass selection however, useful in maintaining the type did not go very far in producing new improved strains of crops Cotton was the first crop to receive attention and the Special Officer appointed in 1916 was raised to the status of Cotton Breeder in Sind in the year 1920 The plant breeding work was then extended to wheat, subsequently to rice and other crops It soon became apparent that the breeding of improved types of crops was the most profitable line of work since it involved no extra expenditure to be incurred by the cultivator in the use of improved seed Hence this work became the most important and popular activity of the Agricultural Department in Sind With the opening of the Agricultural Research Station, Sakrand in 1926 as the result of Lloyd Barrage Canal Scheme, Government decided to appoint an Economic Botanist to deal with the breeding of crops in Sind assisted by the Cotton Breeder and other staff The Botanical Section is now one of the most important Sections of the Agricultural Department

Objects in view.—The chief aims kept in view in breeding of improved types of crops in Sind have been greater production per acre and a readily saleable produce. To achieve these objects, the following characters of the plant have received the greatest attention and detailed study —

(1) Hardiness to withstand the climatic conditions of Sind particularly high temperatures, hot winds, and frost.

(2) Resistance to diseases and pests

(3) Period of growth as limited by conditions prevailing in the well defined tracts of the Province such as water supply, optimum time of sowing, appearance of certain pests, etc

(4) Quality as judged by market demand, and out turn, *e g*, ginning out turn,

Methods employed.—The chief methods employed are—

(1) *Selection*. (*a*) Collection of bulk samples from villages, (*b*) Isolation of types, (*c*) Selection of single plants in the promising types, (*d*) development of the best strains.

(2) *Acclimatisation*.—(*a*) Collection of varieties and types from different parts of India and abroad (*b*) Selection of single plants, (*c*) fixing acclimatised strains.

(3) *Hybridisation*.—Crossing of two types both indigenous or one indigenous and the other imported and acclimatised in order to combine the desirable characters.

In all these methods of plant breeding the pure line theory and the maintenance of single plant tradition in the progeny rows have played an important part and have resulted in maintaining the new type in its original form. When a pure line has been established, it is multiplied and tested in different parts of the Province and if satisfactory results are obtained, it is issued for distribution in the district. Such tests are very rigid and are spread over several years before the improved types are recommended to zamindars. The result has been that only few improved strains have been issued to the Public and all have stood the tests and none of them has so far been rejected. This rigid testing in the district and carrying out these tests for a number of years before issue has been the secret of success in the introduction of improved types of crops in Sind. The Departmental organisation for the multiplication of the pure seed of improved varieties of crops is based on 'unit' system, each unit representing a definite number of acres to be covered with the improved variety in a five year period of time. This system has the advantage of being easily expanded at any stage to meet increasing demand. The seed multiplication scheme consists of five stages, viz. :—

(1) Seed patch located at the Research Station,

(2) Increase block located at Government Demonstration and Seed Farm,

(3) Field scale planting located at 'A' class registered growers or zamindars,

(4) 'B' class registered growers or zamindars, (5) District cultivation.

The greatest disadvantage of such schemes is the extent to which reliance must be put on non-official agencies for the multiplication and distribution in the later stages. This organisation however, has been very successful in the multiplication of pure seed of improved varieties of cotton.

Each year large quantities of seed of improved varieties are distributed with a view to drive out the ordinary mixed and unimproved seed used in the country.

APPENDIX V, C.

(Note by Mr. K. Ramiah, Genelicist, Institute of Plant. Industry, Indore).

Introduction.

Systematic studies in crop plants and breeding superior types out of them may be said to have begun in India in the first decade of the present century, the crops to receive attention first being cotton, wheat and sugarcane. Rice was taken up soon after, but work on millets, oilseeds etc, was started much later. Although every provincial department of agriculture began with an Economic Botanist for the study of crops, later policy had led to the appointment of a number of crop specialists each confining his attention to particular crop or crops. It can be said without fear of contradiction that breeding better types of crops is the most important and popular activity of the agricultural departments, since the advantage of the improved types can be easily demonstrated and the cultivator is not obliged to incur any additional expenditure.

Aim in Breeding.

The ultimate aim of all breeding work is to obtain new forms of crops the cultivation of which will bring a greater monetary return to the cultivator. Greater monetary return is essentially a question of greater acre yields. Even in crops where 'quality' is important as in cotton and sugarcane, yield is still the predominant factor to go for. If quality can be combined with yield all the better, but quality without adequate yield is not likely to be of any help. In cotton it is known that a ten percent improvement in lint quality can compensate only one percent improvement in yield. That a sufficient premium is not obtained for quality is not due to any fault of the grower but in part due to the want of an efficient marketing organisation and to the varied interests of the intermediaries who come between the grower and the consumer. Quality in food crops which are consumed locally and in which there is no export trade is not of general importance. Quality in such cases is also difficult to describe as it is only a question of appearance and taste which requirements again vary from place to place. A fine rice of Madras would be considered coarse in the Punjab; the Central Indian wheat consumer will prefer *chapatis* made out of Malwa (durum) wheat while *chapatis* made out of bread wheats may be preferred in the Punjab and the United Provinces. The quality here has no bearing to the nutritional value. In rice, kinds of poorer quality are found to be the more nutritious. Research on the relationship between nutritional value and local preferences is worth undertaking.

Results already achieved

That the results of plant breeding in India have been tangible can be seen from the area devoted to improved types, and figures (1934-35) for four of the important crops are given below :—

	Area under crop	Area devoted to improved types	Percentage
Rice	81,950,000	3,306,452	4·0
Wheat . .	34,491,000	6,535,546	18·9
Cotton . . .	23,530,000	3,516,508	16·0
Sugarcane . .	3,474,000	2,525,900	72·6

The figures show a big difference among the four crops. Principally due to the comparatively simpler technique involved in breeding sugarcane, the improvement attained in the new types has been so striking that it does not fail to convince the most conservative of growers. While such phenomenal improvements can be realised in seed crops like rice and wheat the area under these is so extensive

the conditions under which they are grown so varied that even a small improvement would amount to a substantial increase in output. Because of the fact that the produce is almost completely consumed in the country it is not possible to estimate the area under improved type accurately. In fact the actual percentage of area under improved types of rice in Madras is far greater than that shown here. This is probably equally true of Bengal and Burma also where breeding work has been going on for a much longer time than in other provinces.

Method of breeding.

The work of breeding has been carried on along the traditional lines of selection, introduction and hybridisation. The first line of work which has now been reduced to a routine has been most fruitful of results, the amount of success obtained by a particular breeder being proportional to his natural intuition and the scale on which he has been handling the material. There is no doubt that there is still a wide scope for this work in India in all crops. While the results achieved have been appreciable it might be said that they are not quite commensurate to the trouble taken. The reasons for this may be partly due to the conditions beyond the control of the breeder and partly to conditions which the earlier breeders either did not realise or did not have facilities to meet them. The great range of agricultural and climatic conditions under which a particular crop is grown in different parts of the country has resulted in special local adaptations and it is more an exception than a rule that a variety doing well in one tract gives a satisfactory crop in a different tract. Apart from varietal diversity in any particular locality which consists mostly of differences in morphological characters, it is the physiological adaptation that gets upset when a variety is moved from one place to another. This should naturally mean that there should be a sufficient number of breeding centres for each crop one in each of the important tracts. The results obtained at the research stations will have to be supplemented by a large number of trials actually carried out in the cultivators' fields. It is the results from such trials that should decide the release of any improved strain. These trials if carried out on a large scale in any tract will be a help to delimit the areas suitable for particular strains. The importance of these trials has been recognised and some provinces are already carrying them out, but what is probably needed is a perfect cooperation between the breeder and the circle officer concerned and a well thought out plan of work. Thanks to the help of the statisticians, the methods of conducting such trials have been very much simplified and subordinates of the agricultural departments with a little training should be able to manage the trials satisfactorily.

Deterioration of strains.

Every one is probably aware of the common complaint that a strain 'runs out' after some time. There may be special causes contributing to such deterioration. In the case of sugarcane where this complaint has been rather loud, it is known that the deterioration is due to the growing of the high yielding Coimbatore types in the same land repeatedly without any rotation and without any attempt to fertilise the fields. The ratooning is also known to encourage pests and diseases to which the cane ultimately succumbs. In the case of grain crops such deterioration has invariably been proved to be due to the type getting mixed up with other inferior types. The author had an occasion once to try a particular strain of rice released five or six years previously and when seed of it obtained from a cultivator who was known to maintain it pure was tested there was no sign of any deterioration. Fairfield Smith (1935) has however mentioned a case in America where some of the wheat strains from Turkey Red wheat which were very much better than the control to begin with ultimately came down to the level of the control after some years. This point is rather important and needs looking into in several of the Indian crops as such deterioration is hardly a thing to be expected to occur in a self fertilized crop. In the case of selections from hybrids, they are known to throw "off types" after some generations, (Engledow 1933) and the gradual deterioration in this case might be attributed to a residum of impurity and the decreasing percentage of heterozygosity from generation to generation. This point should take us to the consideration of the question of limits of selection.

Limits of Selection.

When once a pure line has been obtained can it be further improved by selection?. Some years ago the answer to this question would have been an emphatic no. The author had once to try this in vivo at the suggestion of F. R. Parnell who was the

Economic Botanist in Coimbatore. A certain number of single plant selections from an already established strain was compared against the strain with the result that the yield differences among them were hardly 2 to 3 per cent, considerably within the limits or error. The comparison was, of course, for yield only. It has to be remembered however that the field technique was hardly perfect fifteen years ago and it is possible it was not delicate enough to bring out small differences. In cotton Harland has proved that even after 10 years of continuous selfing it was possible to improve the lint index by further selection. In the case of other crops the question has not apparently received any attention A special technique has been evolved by Hutchinson and Panse (1937) which is being adopted at the Institute of Plant Industry, Indore and this has shown the possibilities of improving the types by repeated selection not only in cotton but also in several other crops like wheat, jowar, linseed, gram etc. The techniqun has been found useful not only to assess yield but also various other characters as lodging of straw in *Jowar*, will resistance in cotton, frost resistance in linseed, etc. A strain the purity of which is determined usually by its morphological characters need not necessarily bn so for yield factors. Fairfield Smith's observations might probably be explained that the original selections consisted of a number of genotypes some better than others and deterioration was caused by the gradual increase of the poorer ones. It is possibln to get over this difficulty by having a small replicated progeny row test continuously and weeding out the poorer genotypes This investigation should appear very important and might be undertaken on a wider scale on all crops. This technique of replicated progeny row test is also useful in getting thn most out of any available material before fresh material is handled

When it is now known that the theoretical homozygosity is never attained particularly in the case of quantitative characters the breeder has to decide at what stage a particular strain should be released So long as the strain has attained a high degree of purity in all commercial characters, and its superiority definitely proved there is no reason why it should be withheld The maintenance of purity in the nucleus stocks at the experimental stations and the organisation necessary for systematic multiplication and spread of the strain are outsida the scope of this noto and are not discussed here.

Improvements in breeding technique.

Yield is the main consideration in a breeding programme but still it would appear comparatively useless from the breeding point of view to choose plants for crossing mainly on their final performance as regards yield. Yield is not a simple factor to lend itself to any genetical analysis Rasmusson (1933) has calculated that at least 100 to 200 genes must be concerned in the inheritance of yield Analysis for yield is intimately associated with complicated physiological processes occurring during the life of a plant in all its separatn organs and any given yield may he built up in *a number of different ways* Developmental studies are of some help to the breeder in identifying such of the components as have the greatest effect on the end product.

The usual procedure in breeding has been to continue the selection in F_2 F_3 and
While the basis of selection is
by crossing, the technique usually
Though comparison of selections
ion the aim of the breeder should
. value at which he is aiming.
es could bn transferred from one
His technique is to back cross
ishes to improvn and select from
the back cross progenies rather than from the F_2S The technique may not be directly applicable to cereals like ricn ond wheat. Direct selection from F_2 onward in those crops for higher yields has not resulted in any outstanding forms. Th several useful results obtained so far have been in the way of improved ancillar characters such as earliness, stronger straw, disease resistance etc., combined probabl with a small increase in yield Another useful method as applied to these crops migh consist of making repeated crosses among selected progenies from thn F_2 onward until the mean of *the characters sought after is raised to the desired level* Th method is under trial for rice in Coimbatore.

Application of Genetics and Cytology to plant breeding.

According to Engledow (1930), Watkins (1934) and Bell, (1937) the successes i plant breeding have come about more on account of new problems, new areas and to th experience and skill of the breeder rather than on the application of genetical principles It is true that the value of genetics to plant breeding has been over emphasized in th

The same view was supported by the All-India Board of Agriculture, which in 1924 unanimously passed a resolution to the effect that the first step in any attempt to improve statistics should be to appoint a Statistical Assistant with an adequate staff under each Director of Agriculture. The Indian Economic Enquiry Committee (1925) also considered the improvement and amplification of existing agricultural statistics. The Committee was well aware of the unsatisfactory character of agricultural statistics and has stated in clear terms —"There can be no denying the fact that from the point of view of economic data the agricultural statistics are defective." The Committee recommended the establishment of a Central Statistical Bureau at the headquarters of the Central Government, to take the place of the Statistical Section of the office of the Director General of Commercial Intelligence and Statistics for the purpose of centralisation of statistics. It further recommended that every Province should have a Provincial Statistical Bureau with a Provincial Statistician at its head and a staff of Assistants. With such a consensus of advice from the highest authorities it seems unnecessary to justify further the need for the appointment of a Provincial Statistician. The writer submits that, for many years past, too little stress has been laid on the interpretation and technique of the statistical work. Take the case of rainfall statistics. We have the *daily* rainfall data for over *200* stations for almost *50* years and yet beyond the voluminous compilation of all this data and the preparation of periodical (Weekly, monthly or annual, as the case may be) reviews no comparative study of this valuable data over a series of years has been attempted, say, by means of curves, nor has it been possible to study the more important question of how much of the rainfall received has been really useful, how much has been lost in run off etc., and how much has been definitely detrimental to crops. An attempt in this direction was made by Dr. Mann who had tentatively framed certain rules for calculating the "*effective*" rainfall. Thus, a rainfall below a certain amount had to be ignored, that above two inches in a day had similarly to be discarded, while rain which occurred at the time of harvesting of the *Kharif* or *rabi* crops was to be taken as injurious, etc. A number of curves for representative stations in the Presidency showing the effective rainfall were drawn and in some cases like Poona and Bombay, data was collected for 70 or 75 years. The results appeared promising as, by a comparison of the curves, it appeared to be possible to indicate some forecast of the agricultural outlook for any season. This question was latterly shelved and has never been reopened, although it would be very desirable to proceed with the study, if adequate staff for the purpose was available.

As regards price statistics no weekly, monthly or annual review is made except in Chapter VII of the Season and Crop Report. In fact, all that is done with regard to price statistics is to compile and publish them for both retail and wholesale prices for a number of stations monthly and/or fortnightly, after removing obvious discrepancies. As stated in the Report on the Marketing of Wheat recently published, these price statistics are very defective, the retail prices are sometimes cheaper than wholesale prices, the average quality of the article for which prices are quoted is not the same at each station, there is confusion in the units of measurement and so on; but apart from these defects the chief defect is that they have never been studied over a series of years with a view to find out, say, by means of curves, their trend *i.e.*, whether there is a tendency to rise or fall in certain cases and at certain periods and what is more important to find out whether the variations are due to local conditions (*e.g.*, more or less local production) or to change in the habits of the people *e.g.*, the tendency of the people of switching from *gur* to sugar or from jowar to bajri, etc., or to world factors *e.g.*, world depression, tariff changes, increase or decrease in the produce in foreign countries, etc., etc. We have got both retail and wholesale prices for a number of articles and stations, on record for almost *50* years which could very well be utilized for working out the cost of living index and in finding out the variations in the purchasing power of the rupee.

As regards general statistics, these relate mainly to the area and yield of crops but even in this case, more attention is paid to compilation than to interpretation. The area figures of the different crops are published periodically in Crop Forecasts and in the Season and Crop Report during each year but no attempt has been made to tabulate the areas under the different crops for, say, 30 or 40 years and to find out the changes or the reasons for these changes. A comparison of the area under groundnut or under tobacco now, as compared with some 30 years back will show that there has been a tremendous change. As regards yield data, in addition to the statistics of crop outturns published in the Forecasts and in the Season and Crop Report, a statement showing the average yield per acre of principal crops is sent every five years to the Director General of *Commercial Intelligence and Statistics*, but even in this case no attempt is made to arrive at the data by means other than the crop cutting experiments, nor is the position surveyed with a view to see whether the yield per

acre is increasing or decreasing, say, during the course of the last 30 or 40 years and how far the increase, if any, is due to improved seed supply, better methods of cultivation, introduction of improved varieties as a result of the efforts of the Agricultural Department, etc, etc, or how far any decrease is due to erosion of the soil, deterioration in the economic condition of the cultivator, recurrence of bad seasons etc., etc. This would be a very interesting and profitable study.

The form in which agricultural statistics are published also leaves much room for improvement. A comparison of our Season and Crop Report with the Year Book of the United States' Department of Agriculture will show that while the former contains a short paraphrase in letter-press of the figures shown in the statements, the latter is a much more interesting, useful and comprehensive publication.

In short, the way in which agricultural statistics are dealt with at present leaves much room for improvement—less in compilation, more in presentation and most of all in interpretation With the existing statistical staff it is impossible to effect any real improvement and a Statistical Assistant with two senior hands is, in my opinion, the *minimum* requirement to start with. Although improvement in the compilation and presentation of the statistics would be among the main duties of such a staff they would also be expected to take up other problems connected with agricultural statistics and to endeavour to prepare the way for a systematic review, examination and interpretation of the large amount of accumulated statistical data in the Presidency.

APPENDIX VI, C.

Note on All-India crop forecast improvement scheme.

(G. R. AMBEKAR, *Principal Officer in charge Cotton Forecast Improvement Scheme, Bombay Presidency*).

The importance of correct crop forecasting is too well known to require any mention. Realising this, the Government of India and the Provincial Governments have been issuing crop forecasts for over half a century but the position continues unsatisfactory and the estimates are wide of the mark. The special investigation being carried on in connection with the improvement of the Bombay cotton forecasts with the financial aid of the Indian Central Cotton Committee since 1934 has shown that *all* the three factors on which the *crop forecasts are based, viz., (1) the area* (2) the anna valuation and (3) the standard yield figures are inaccurate. In the case of area there are instances on record where the area reported from a certain group of States, for example, for the first two forecasts issued in October and December (i.e., fully two to four months *after* the completion of the cotton sowings) has been only between 6 to 8 lakhs of acres against nearly two millions acres reported for the final cotton forecast, *for the same season*, issued subsequently in April! Similar *irregularities are also noticed in the case of British Districts. Confusion* between the units of measurement as between *bighas* and acres has also been found to be responsible for a wrong estimate to the extent of 100,000 bales of cotton in one group of Indian States alone!

As regards the standard yield figures, these are very much ante-dated, there being cases where no revision could be made for want of data for the last 20, 30 or even 50 years. Similarly, these figures are not available separately for irrigated and un-irrigated crops in all cases. Further, in the absence of separate figures for the Indian States, the practice is to apply the figure of the nearest British District to work out the outturn in States but the Bombay cotton forecast investigation has clearly shown this practice as definitely wrong.

As regards anna valuation, *i.e.*, the estimation of the condition factor, it is mostly an eye estimate and hence only approximate. Besides, it is mainly done for purposes of land-revenue which is based upon it. Experience has shown that for other purposes like crop forecasting, this valuation work is neglected.

The severe official and non-official criticism of the Bombay castorseed and groundnut forecasts a few years back, the very wide difference in the estimate of tobacco outturn framed by the local Officers and that framed by the Agricultural Department on the basis of the old standard yield figures, all go to confirm the unsatisfactory character not only of cotton crop forecasting, but of crop forecasting as a whole, at least in the Bombay Presidency.

the area figures are now much better than formerly. As for anna valuation, it is the basis for the collection (or for suspensions and remissions) of land revenue. It is, thus, an administrative question and so cannot be tampered with but even in this case it has been found that by making a certain allowance on the basis of previous experience, it is possible to improve appreciably the forecast estimate With regard to the standard yield figures, the work in connection with the Bombay scheme has also shown that although systematic crop cutting experiments are the best means to revise the figures, much can be done to revise them in the light of other data, *e.g.*, collecting yield data from experienced Officers and cultivators, by tabulating and interpreting data available with the Agricultural and Revenue Departments in their Annual Reports, Experimentel Station Rerords, Settlement Reports etc., by dividing the actual crop by the area over a series of years etc, etc. The results obtained with the figures revised tentatively with such data have confirmed this view in the case of Bombay Further, the Bombay investigation has shown that by making allowance for the various irregularities, by the collection of relevant statistics of the movement of crop, by discussion with experienced officers, cultivators and trades people and by seeing the crop in person at numerous centres, it is possible to make independently a more accurate estimate of yield than the Government forecast of such yield. The attempt made last season (1936 37) in the case of three areas including in the Bombay scheme has given very enrouraging results in this direction, in all the three cases. The investigation has further brought home the importance of collecting end interpreting supplementary data, *e.g.*, movements of the crop, Trade estimates (ginning returns in the case of cotton) etc., etc.

It will thus be seen that by extending the scope of the Bombay Cotton Forecast Improvement Scheme so as to include the more important crops on which forecasts are issued and the various Provinces and States of India, it is possible to improve the position of crop forecasting very appreciably without incurring any prohibitive expenditure either on increasing the village staff, *i.e.*, the Reporting Agency or on carrying a very large number of crop cutting experiments over a series of years Further, the necessity of improving the forecasts of *all* crops (for instance, the anxiety shown by the Imperial Council of Agriculturel Research for the improvement of the statistics of wheat production and for the issue of forecasts on certain cereals and pulses) and the importance of correct crop forecasting to other very important all-India investigation like the Marketing of Agricultural produce etc., show the necessity of an all-India Crop Forecast Scheme.

Besides, an all-India Forecast Scheme is not a new idea. Even in 1932 the Indian Central Cotton Committee came to the conclusion that it would be profitable to engage a man to study and to report on the system of (cotton) crop forecasting in India and abroad. This view has been further endorsed by high authorities. An all-India Scheme will be carried on with an all-India outlook which is essential and there will be uniformity in the method followed On the other hand, having a Scheme for one crop or for one Province now and for another crop or Province afterwards will be like patch work Much time will have to be spent on spade work, as each Provincial Officer will have to spend a good deal of time in such work The Bombay Scheme has shown that even for a provincial scheme it is essential to go beyond the geographical limits of the Province to ascertain how far the problem is affected by conditions in the surrounding areas (*e.g.*, the imports of loose cotton in Bombay from Hyderabad Deccan inflate the press figures and make the Bombay cotton forecast for the Deccan, *appear* to be an underestimate) As the all-India forecast is a consolidation of the Provincial forecasts, it is also evident that to make the former accurate the latter must first be improved An investigation in the various Provinces of India may bring to light certain good points in forecasting in some Provinces which (with local modifications) can be utilised to advantage in the other Provinces. Data collected in one Province may also serve as a check on similar data collected in adjoining Provinces. When once the Central and the Provincial Governments have undertaken the issue of crop forecasts as their duty, it is essential that these forecasts should be accurate since the public naturally look upon any information issued by Government as authentic In any case there is no reason for the Government forecasts being less accurate than the Trade estimates An all-India and *all* crop forecasting scheme can also legitimately look forward for financial help to the Indian Central Cotton Committee, the Imperial Council of Agricultural Research and also to the Government of India as these are *all* interested in the improvement in all-India crop forecasting If this view is accepted, the cost per head will be very small and such as can easily be borne without waiting for the improvement of finances This is an important consideration. Besides, only recently

the Indian Central Cotton Committee and the Imperial Council of Agricultural Research jointly financed the Economic Enquiry into the cost of production of cotton and sugarcane at a total cost of about 5½ lakhs of rupees. If that enquiry was worth this cost and joint financial help, the all-India Crop Forecast Scheme (which has been acknowledged to be of such importance by all, not only for its own sake but for other important all-India Schemes like the Marketing Survey and Crop Planning), is certainly worth similar help.

Considering all factors, an all-India Scheme of crop forecasting seems not only desirable but quite essential. Assuming that the all-India Scheme will be carried on on the lines of the Bombay Cotton Forecast Improvement Scheme, the period required will be about ten years and the expenditure required will be about two lakhs of rupees including study of the problem abroad as shown below :—

Name of Head.	Estimate of cost.										Total
	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year	
Pay of Officers.											
One officer in charge of the scheme in the grade similar to that of a Marketing Officer, viz., Rs. 500 to Rs. 900	6,000	6,480	6,960	7,440	7,920	8,400	8,880	9,360	9,840	10,320	81,600
Pay of Establishment.											
(1) Senior Clerk in the grade of Rs. 60—5/2—75	720	720	780	780	840	840	900	900	900	900	8,280
(2) Clerk in the grade of Rs. 25—5/2—50 starting on Rs. 30	360	360	420	420	480	480	540	540	600	600	4,800
(3) Three peons (one on Rs. 17, one on Rs. 18 and one on Rs. 19)	648	648	648	648	648	648	648	648	648	648	6,480
Total .	1,728	1,728	1,848	1,848	1,968	1,968	2,088	2,088	2,148	2,148	19,560
Allowances and Honoraria.											
Travelling Allowance for the Officer	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	55,000
Travelling Allowance for the Establishment	800	800	800	800	800	800	800	800	800	800	8,000
Total . .	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	63,000
Contingencies.											
Non-recurring for furniture, typewriter, etc.	600	..	..	..	..	..	..	..	..	..	600
Recurring for Office expenses and Miscellaneous, service postage stamps, stationery, forms, books and publications, etc.	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	14,000
Total	2,000	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	14,600
Grand Total .	16,028	15,908	16,508	16,988	17,588	18,068	18,668	19,148	19,688	20,168	1,78,760

Cost of study of the crop forecasting problem, abroad, *i.e.*, outside India . . . . . . Rs. 10,000

1,88,760 or say 1,90,000

It is assumed that the pay given to the Officer in charge of the Scheme will be about the same as given to *senior* Officers (say, the Marketing Officers) in the Marketing Scheme now working or to the head of the Economic Enquiry recently completed, both of which are all-India investigations. This expenditure, as will be seen, is only a fraction (i.e., only about one-third) of the cost of the Economic Enquiry. Further, if the cost of the Forecast Scheme is shared by the Indian Central Cotton Committee, the Imperial Council of Agricultural Research and the Government of India, as is suggested, it will be only about Rs. 6,500 per head per year, which will be admitted as very moderate.

To summarise, from the present unsatisfactory position of crop forecasting in India, it appears that at one time or other the problem must be tackled from an all-India point of view. The Bombay Scheme has further shown that by closer personal check and by obtaining supplementary data, much can be achieved without touching the primary reporting agency, the reorganisation of which would mean prohibitive cost. The all-India Scheme is not, thus, a mere experiment but is justified in every way and the expenditure would seem to be fully worth while.

APPENDIX VI, D.

(NOTE BY THE SECRETARY, I.C.A.R., CONTAINING NOTES FROM RAO BAHADUR M. VAIDYANATHAN, *STATISTICIAN, I. C. A. R.* AND DR. W. BURNS, *AGRICULTURAL EXPERT TO THE COUNCIL.*)

The attached note (annexure I) by Rao Bahadur M. Vaidyanathan, Statistician, Imperial Council of Agricultural Research, is for the consideration of the Board. The Imperial Council of Agricultural Research have examined the question of crop statistics on various occasions and the attached copy of a note (annexure II) by Dr. W. Burns Offg Agricultural Expert to the Council states in brief the action taken by the Indian Central Cotton Committee and the Imperial Council of Agricultural Research in certain cases and the action which the Indian Central Jute Committee are taking in respect of jute. In addition it may be mentioned that as a result of a recommendation made by the Crop Planning Conference, 1934, Provincial Governments have been addressed by the Imperial Council of Agricultural Research on the question of issuing regular crop forecasts in respect of *Jowar, Bajra, maize* and other millets, barley, gram and other pulses and *Kharif* pulses The Government of India have also taken up the question of amplifying the rail-borne trade accounts and have appointed a committee in this connection

ANNEXURE I.

NOTE BY RAO BAHADUR M VAIDYANATHAN, M A, L.T., F S S, STATISTICIAN, IMPERIAL COUNCIL OF AGRICULTURAL RESEARCH, INDIA

INTRODUCTION.

The nature of the agricultural statistics published so far may be broadly classified as follows :—

(1) *Crop forecasts* of area and yield for ten crops only (Rice, Wheat, Cotton, Jute,* Linseed, Rape and Mustard, Sesamum, Groundnut, Castor seed, Sugacane) issued periodically and published in *Indian Trade Journal* by the Director General of Commercial Intelligence and Statistics, the number of forecasts issued depending upon the importance of the crop presumably from trade standpoint (Vide Appendix I).

(2) *Estimate of Area and Yield* of Principal Crops in India (published by the Director General of Commercial Intelligence and Statistics) issued annually for thirteen crops with supplementary tables for seven crops (*Vide* Appendix I), which include (a) *Yield per acre* of the thirteen crops for the ten years preceding the year to which the publication relates (b) *Standard or normal* yields per acre of those crops for which forecasts are issued (c) Normal and actual rainfall in each province and (d) reported areas of yields for certain crops only in foreign countries

(3) Current Prices of some important agricultural commodities published weekly in the *Indian Trade Journal*, and also wholesale prices of certain staple articles of trade at selected stations issued quarterly.

(4) Other agricultural statistics included in "Agricultural Statistics of India", Vols. I and II, (also published by the Director General of Commercial Intelligence and Statistics) which deal, among other things, with Classifications of areas (areas under forests, those not available for cultivation, culturable waste other than fallow, current fallows, net area sown and total), irrigated and un-irrigated areas, the numbers of livestock, ploughs and carts, incidence of the land revenue assessment on area and population, and harvest prices. Vol. I of "Agricultural Statistics" deals with British India, and Vol. II with Indian States, and information is given for each individual district for each province. Besides these important publications we have "*Statistical* Abstract for *British* India" published annually by the Director General of Commercial Intelligence and Statistics (Including Statistics where available relating to certain Indian States), Quinquennial report on the average yield per acre of principal crops in India (which data are also summarised by provinces in "Estimates of Area and Yield"), and Live-Stock statistics published annually.

* Published by the Director of Agriculture, Bengal

Special supplements of *Indian Trade Journal* are issued now and then (not regularly) dealing with statistics of tea, rubber, coffee and tobacco. The trade movement of agricultural commodities is supplied by the following monthly publications :—

Accounts relating to the *Sea borne trade* and navigation of British India,

Accounts relating to the *Coasting Trade* and navigation of British India, and

Accounts relating to the *Inland* (Rail and River-borne) *Trade* of British India.

'Review of the Sugar Industry of India' is a very useful publication, and also 'Review of the Trade of India', published annually. 'Cotton Map of India', and 'Crop Atlas of India' (the latter was published for the last time in 1935) give very useful information.

These are all publications of the Director-General of Commercial Intelligence and Statistics (Government of India), and the provincial governments publish annually their 'Season and Crop Reports', and also their own trade figures and prices periodically.

METHODS FOR THE COLLECTION OF AGRICULTURAL STATISTICS.

(a) *Methods for framing estimates of crops*

Areas.—The details of the methods adopted in framing estimates for crops and the collection of statistics are given in Appendices I and II of 'Estimates of Area and Yield of Principal Crops in India'. Three factors enter into an estimate of out-turn (*i.e.*, area, the standard normal out-turn per acre, and the condition factor whose product gives the quantitative out-turn) Of these, the *area* figures are considered to be fairly accurate (except in permanently settled tracts like Bengal and Bihar and in lands held on privileged tenure, and unsurveyed lands). It seems necessary to improve the accuracy of the area figures in these latter tracts, which can best be done by proper sampling methods applied to specially selected areas and knowing the extent of error between the actual figures and sampling data Taking the case of Bengal and Bihar, the simplest course seems to be to divide the province into five (or a larger number of) tracts, and then to apply proper sampling technique for each crop in specially selected areas (got by randomisation) in each tract, which will give a measure of divergence between the actual and those sampled. It would be advisable in the beginning to take as large a number as possible of areas for each tract and also of samples to be taken in each area Once the variance (or the extent of variability) between areas, and between samples in each area is known, the actual number of areas to be taken in subsequent years for each tract and the number of samples for each area can be determined, consistent with any standard of accuracy desired.

Standard Normal Out-turn per acre.—The second factor that enters into the computation of the total yield is *Standard Normal Out-turn per Acre*. The method that is now adopted in some of the provinces is what is known as the method of "Crop-cutting experiments"; by which samples of yields are taken from different fields in a locality from which average yield per acre is calculated.

The general defects in any methods that have been adopted or suggested so far (*e.g.*, Hubback's method in Bihar, and the methods now adopted in United Provinces) for arriving at an average yield are that the samples of fields selected have not been unbiassed besides the inadequacy of the number sampled, and that the sampling within the field is equally not unbiassed besides being insufficient. General experience has shown that the only way of removing *personal bias* is *randomisation*, and that the number of fields to be taken in each locality depends upon the degree of accuracy desired. Therefore, for future experiments it seems necessary that each district should be divided into three (or more) sub-divisions, that in each sub-division a certain number of 'areas' should be selected at random, and that in each "area' twenty-five fields—or a larger number—taken at random, should be harvested depending upon the variation of field to field Within each field a number of sampling units should be taken, free from personal bias; and this can best be* done by marking along a diagonal of the field as many points as the number of units necessary at equal pacings between point and point, and cutting the crop at each point† an area covered by a circular hoop (say an area of 10 square feet). Experience has also

* This is the method arrived at after discussion with the Statistical Department, Rothamsted. † The point selected will be at the circumference of the hoop.

shown that so long as personal bias does not enter into the selection of sampling units we get satisfactory results, and the above method eliminates such a bias. By analysis of variance of yields, we may separate the sampling variance from variance due to 'between fields', and judge the adequacy of sampling. The number of fields n to be sampled in a locality consistent with a standard of accuracy desired can be calculated by the usual formula :—

$S/\sqrt{n} = x$ (Where S is S.D. and x the standard error to be attained).

If for example field to field standard deviation in a compact area be of an order of twenty per cent. of the mean, then to attain a standard error of two per cent. the number of fields required, is got from the equation .—

$$\frac{20}{\sqrt{n}} = 2 \text{ which gives } n = 100.$$

A hundred fields are therefore necessary on this basis, in a fairly compact area, to attain a standard error of the mean of two per cent. or if we are satisfied with an error of four per cent., the number of fields needed would be twenty-five only.

Condition Factor.—The *condition factor* represents the ratio of the current crop to the normal crop and the normal yield per acre has been officially defined to be 'the average yield on average soil in a year of average character'. Here it is that there are pitfalls as with inexperienced reporters a lot of bias is possible in grading the fields according to their fertility. The *primary reporters report* the *yield as so many 'annas'* of a normal crop, and the weighed average of these is struck for the district and eventually for the *province*. The system of 'Anna Estimates' is based upon the idea that yields should be expressed in sixteenths of the normal and that as a rupee contains sixteen annas a crop might be put down as so many 'Annas' crop. The original intention was that a sixteen anna crop should represent the normal, but as it was found that village opinion regards a sixteen anna crop as a first class crop, in most provinces the normal crop is now equated to twelve or thirteen annas. The accuracy of this system obviously depends upon the intuitive skill of the primary reporting agency, firstly in correctly picturing a normal crop and secondly in visualising a correct marking for the particular crop. But if the reported seasonal factors for a sufficiently long series of years correctly represent the condition of the crop in those years, the average of those figures cannot differ appreciably from 100, representing the normal crop. It has, however, been found that this is not the case, and hence it is necessary to correct the seasonal factor by the formula —

$$\text{The corrected Seasonal Factor} = \frac{\text{uncorrected Seasonal Factor} \times 100}{\text{Average of the uncorrected for a series of years (say 10 years).}}$$

Suggestions for Verifying the Final Estimates.—Besides, the grading itself of the anna estimates has not so far been tested to see whether it secures a correct average : in Madras, for example, the grading followed used to be —

16 as to 13 as/12 as/11 as to 8 as/7 as to 4 as/and,3 as to 0 as

It would be necessary to examine, on the basis of actual figures of anna estimates, taken for a sufficient number of random samples, how far such a grading is accurate.

Apart from rigorous statistical tests that must be undertaken periodically to verify and improve the accuracy of the various factors that enter into the computation of forecasts and final estimates of yield, the final estimates may be subjected to a scrutiny by independent means. If, for example, the statistics of the internal trade of a country combined with export and import figures are available, as they are now in India, then the only other factor that would account for the total produce would be *consumption* for which estimates might be worked out. Obviously there are difficulties for estimating *consumption* in the case of food crops. But in the case of non-food crops the methods of estimation are simpler. The Indian Central Cotton Committee have been publishing figures to show the extent of discrepancy between

the final estimates, and the figures worked out on the basis of consumption and net exports. The following method adopted by the Committee may be of interest (*I.T.J.* May 1937) :—

RAW COTTON POSITION IN INDIA FOR YEAR ENDING 31ST AUGUST.

	1936 Thousand bales (400 lbs.	1935 Thousand bales (400 lbs.)
Exports.	3,826	3,115
Home consumption (in mills and including extra-factory consumption, which is a conventional estimate)	3,428	3,362
Approximate Crop*	7,254	6,477
As estimated in the final forecast . . .	5,933	4,857
Excess . . .	+1,321	+1,620
Per cent. excess about . .	22 per cent.	33 per cent.

*(Carry-over from one year to another is not taken into account, as complete information of stocks is not available).

It is thus seen that with more information that may be obtained with regard to stocks, accurate information is possible to know the extent of discrepancy between the two methods.

The other method of verifying the forecasts and final estimates—by far the most satisfactory method—is by a continuous process of sampling observations on different factors of plant growth (such as tillering, short number, etc.) and correlating them with the final yield. Such studies are now being usefully undertaken by the Agricultural Meteorological Section of the Imperial Council of Agricultural Research, and need encouragement.

The correlation of meteorological data with the yields is another piece of useful research that should be extended to all agricultural stations, which would verify the crop forecasts and final estimates. Some work has already been done by the Agricultural Meteorological Section of the Imperial Council of Agricultural Research, and this should be elaborated. The Imperial Council of Agricultural Research might undertake a general statistical examination of the methods of crop estimation by the various methods suggested above.

METHODS FOR THE COLLECTION OF AGRICULTURAL STATISTICS.

(b) *Enlargement of the scope of the data.*

From the nature of the statistics collected at present (given in the Introduction) it is seen that there is need for widening the scope of the present data. Thus the number of crops for which forecasts are issued at present is ten only, and it seems necessary to increase this number so as to include crops which are important from the point of view of internal movement. For example, food crops like Barley, Jowar, and Maize are omitted from the list; and so also are gram and tobacco, which are all-important from the point of view of movement from one province to another. Coffee and Tea are occupying important places in International Trade, for which, too, forecasts are not issued. The list of forecasted crops thus needs a revision. Similarly, the number of forecasts issued for each crop has also to be revised; thus while wheat and cotton now have *five* forecasts, sugarcane has only *three*, and jute only *two*. This too requires an examination to see whether from the point of view of both external and internal trade this list cannot be revised. The list of commodities included in the supplementary tables of 'Estimates of Area and Yields' also needs a revision

Rice Statistics.—The publication of prices of agricultural commodities at chief markets in each province from time to time (say weekly) is necessary end important from tho point of view of the agriculturist. The All-India publications dealing with prices are the weekly 'Indian Trade Journal', and also 'Wholesale Prices of Certain Staple Articles of trade at Selected Stations in India' issued quarterly. An examination of whether the list of agricultural commodities for which weekly prices are issued, end also the list of markets for those commodities cannot be widened seems necessary The sources of information for obtaining the prices need elso an examination

The method of computation of harvest prices published in provincial and Season Crops Reports (and long after the duo date in Agricultural Statistics) needs scrutiny.

Railway and Sea Freights for Agricultural Commodities—To the agriculturist and the trader the publication of railway and sea freights from centres of produce to the ehief markets, from time to time would be very helpful The list of commodities and the centres for which freights should be published should also be examined, and sueh statistics might well be published in the Weekly Indian Trade Journal

Agricultural Statistics—The scope of tho data published in 'Agricultural Stetistics' (Vols. I and II) should be examined with a view to see whether estimates of yield of tho various erops cannot also be included, though it means a duplication of tho data in 'Estimetes of Area and Yield of Prineipal Crops in India'; but it will givo in a single publication all that an agriculturist needs Computetion of the area figures (such as of culturable waste other than fallow) has not been uniform in all the provinecs, and some sort of uniformity should be etteined by a criticol examination of the whole question The volumes are alreedy bulky, and it needs an exemination to see whether the size cannot be reduced But these publieations would bo useful, only if the publicetions came out quick enough after the year to which the data relate.

Other Publications of the Director General of Commercial Intelligence and Statistics—An examination of the scope of tho data included in 'Statistical Abstract for British India' is necessary

Tho publicetion 'Quinquennial report on average yield per acre' does not serve much useful purpose, es these data by provinces are included in the 'Estimates of Area and Yield of Principal Crops in India', and as the data of individual districts are included in the provincial season and crop reports 'Accounts relating to tho Coasting trade and navigation of British India' and also 'Accounts relating to the Inland (Rail and River borne) Trade of India' should be examined to see whether more crops cannot be included

Special Agricultural Publications—Special Supplements to the Indian Trade Journal issued periodically such as 'Statistics of tea, rubber, coffee and tobacco' might as well be published by the Imperial Council of Agricultural Research, though the Director General of Commereial Intelligence and Statistics always consults them regarding these publications The advantage will be that matters of agricultural interest may also be included, and that the publications may issue more regularly

General—If all these publications should be really useful, they should all issue pretty quickly after the dates to which they relate The actual dates of issue should be settled in consultation with the Director-General of Commercial Intelligence and Statistics.

SUMMARY.

(1) The various publications dealing with Agricultural Statistics of the Director-Geneeal of Commercial Intelligence and Statistics should be examined to see whether the scope of the data included cannot be widened, and whether the size of the publication is at a proper level. It is necessary that all the publications should issue pretty quickly after the dates to which they relate.

(2) Methods of crop-forecasting are discussed in detail; and methods are suggested for improving them.

APPENDIX.

Dates on or about which the All-India Forecasts of Crops are issued by the Department of Commercial Intelligence and Statistics, India.

Rice—		
1st forecast	October	20
2nd forecast	December	20
Final forecast	February	20
Wheat—		
1st forecast	January	31
2nd forecast	March	15
3rd forecast	April	20
4th forecast	May	30
Final forecast	August	10
Sugarcane—		
1st forecast	August	20
2nd forecast	October	20
Final forecast	February	5
Cotton—		
1st forecast	August	15
2nd forecast	October	15
3rd forecast	December	15
Final forecast	February	15
Supplementary forecast	April	15
Jute—		
Preliminary forecast	July	7—15
Final forecast	September	21
Linseed, Rape and Mustard—		
1st forecast	January	1
2nd forecast	March	15
Final forecast	June	1
Sesamum (til or jinjili)—		
1st forecast	September	1
2nd forecast	October	20
Final forecast	January	15
Supplementary forecast	April	20
Castor Seed	February	20
Groundnut—		
1st forecast	August	20
2nd forecast	October	20
Final forecast	February	15

'Estimates of Area and Yield of Principal crops in India', contains Supplementary tables :—Area and *yield of barley, jowar, bajra, maize, gram, tobacco and indigo* in each province.

ANNEXURE II.

I.

COPY OF A NOTE DATED THE 30TH JUNE 1937, BY DR. W. BURNS, OFFG. AGRICULTURAL EXPERT, IMPERIAL COUNCIL OF AGRICULTURAL RESEARCH, REGARDING IMPROVEMENT OF AGRICULTURAL STATISTICS.

* * * * * *

Cotton.—The Indian Central Cotton Committee in 1933 formed a Cotton Forecast Improvement Committee which has met once or twice a year since then and which

has gone over the cotton statistics and made valuable suggestions Still more important is the Bombay Cotton Forecast improvement scheme whereby, on the recommendation of the Cotton Forecast Improvement Sub-Committee, the Indian Central Cotton Committee sanctioned for the Bombay Presidency for a period of two years, in the first instance, a scheme providing the pay and other charges of an experienced whole time officer for effecting improvement in cotton forecasting work carried on in the office of the Director of Agriculture, Poona. This scheme started work on 16th June 1934 The Scheme was extended by three years taking it up to 15th June 1939. This scheme has already detected and rectified several sources of error *e.g.*, different standards for a normal crop in terms of annawari, utilisation of standard yield of adjoining British Districts as the standard yields of certain States, lumping together of irrigated and unirrigated crops and the utilisation of standard yields fixed 30 years ago In addition, the Indian Central Cotton Committee financed an enquiry in all provinces in the amount of cotton utilised for domestic purposes throughout India such as handspinning, making of quilts, mattresses, cordage, etc. This is just completed.

Wheat and Rice.—The first meeting of the Wheat Committee appointed by the Imperial Council of Agricultural Research was held in Simla on the 10th and 11th July 1936 and the improvement of statistics of wheat production was taken up as one of the main items for discussion The Chairman—Sir Bryce Burt—suggested that local Governments should be invited to put up definite proposals for improving the statistical organisation As regards standard yield, the Chairman said the only way to remedy the present defects was by an adequate number of carefully planned randomised crop cutting experiments. A method that had been devised by Mr. Allan in the United Provinces and developed on the advice of statistical experts including Mr. Yates of Rothamsted, was considered to be capable of giving a fairly accurate measure of yield A similar subject was taken up in the Rice Committee of the Imperial Council of Agricultural Research in January 1937 when the necessity for crop cutting experiments was emphasised and as regards area figures, the suggestion that had also been made at the Wheat Committee in favour of a sampling survey was desirable. Mr. Sethi, Director of Agriculture, Bihar, stated in connection with jute how he had recently had a survey made with the help of 30 Amins, 3 Inspectors and a Revenue Officer who covered the whole of the Jute area in Purnea within 7 weeks and found 300 000 acres of jute as against 1,20,000 acres. In conclusion, the Chairman's suggestion for the adoption of a 10 per cent random sample survey for ascertaining crop areas under rice was approved As regards yields, in addition to crop cutting, it was decided to take into account yield figures obtained on demonstration plots and on village plots (trials made under the Agricultural Department's auspices in villages). Mr N. C. Mehta specially emphasised the value of air surveys

Sugarcane.—This matter had been discussed at the Sugar Committee in July 1935 and again at the Sugar Committee in 1937. Crop cutting experiments were again recommended and local Governments accordingly addressed

Jute —The question of area came up very prominently in the first meeting of the newly established Indian Central Jute Committee and money was set aside for the carrying out of a survey I understand that the actual method of carrying out this survey is likely to be modified as a result of certain criticisms and suggestions by Professor Mahalanobis.

Tobacco —On the recommendation of the *ad hoc* Tobacco Sub-Committee (September 1934), efforts have been made to improve the statistics of production of tobacco in the Indian provinces No programme for the improvement of the actual methods of estimating areas or yields was laid down but arrangements have been made for reports from provinces regarding area, estimated yield and the condition of the standing crops, well in advance of the annual returns submitted by them to the Director General, Commercial Intelligence and Statistics for the purposes of the Estimates of Areas and Yield Arrangements have also been made for reporting the areas under the two main kinds of tobacco cultivated in India

General.—I think we shall not get further forward until there is appointed in each province one statistically qualified officer whose business it will be to apply methods worked out in collaboration with Professor Mahalanobis which will be statistically sound and capable of adaptation throughout the whole of India. These methods will have to deal with :

(1) the checking of area,

(2) the establishment of corrected standard yields.

The checking of area ought to be accompanied by a list of the various causes of incorrect reporting of area The officer-in-charge of the improvement of cotton

forecast in the Bombay Presidency has found quite a number of ways in which even in a temporarily settled provinre areas are wrongly reported. These faults can easily be remedied if known. As regards standard yield, an important point insisted upon in one of the discussions by our own Statistician—Rao Bahadur M. Vaidyanathan—is the definition of the area to which a standard yield should apply. Such areas will differ in different provinces and from part to part of the same province and need not be simply revenue Districts as at present. The irrigated and unirrigated crops of the same kind will obviously need to have different standard yields. There is no reason, it seems to me, why the sampling survey for area and the standard yield crop cutting experiments should not be carried on by the same agency. As regards the seasonal factor, it seems to me that this has to be watched and recorded throughout the season by trained observers on the spot. The observer would again have to be the village officer but he ought to be given throughout the season postcards similar to those used by the honorary observers for the wheat survey in Canada carried out by the Winnipeg Free Press, so that as each month passed he could indicate clearly what factors had affected the crops and to what extent he thought the crop had been affected. What we need, then, it seems to me is—

(1) the working out of a correct doctrine by Prof. Mahalanobis, and

(2) the employment of at least one officer in each province who would be charged with the carrying out of this doctrine, also the employment of the staff necessary for area sampling surveys and crop cutting experiments.

In addition, it might be worth while utilising aerial surveys for the checking of sampling done on the ground.

APPENDIX VI, E.
Agricultural Statistics.

(A. M. LIVINGSTONE, *Agricultural Marketing Adviser.*)

Crop Statistics in India are published by the Department of Commercial Intelligence and Statistics in two publications :—

(1) *Estimates of Area and yield of Principal Crops in India.* ("The Estimates"). This publication gives acreage and outturn of important crops only for those British Provinces and Indian States for which forecasts are made.

(2) *Agricultural Statistics of India.* ("Agricultural Statistics"). This is published in two volumes (Vol. I dealing with British Provinces and Vol II with Indian States) and contains statistics relating to area only It is however a more authentic and detailed publication and gives also district figures.

For reference purposes 'The Estimates' publication is found more useful as it is published about a year earlier than the 'Agricultural Statistics', it contains statistics for 10 years while the other publication gives only 5 years and it also gives outturn statistics which are not included in the other volumes.

The suggestions given below are designed to make "The Estimates" publication self-contained and more useful as a reference book without affecting in the least its volume or the time taken in its preparation. The first three of the following suggestions refer to crops in general and the next three particularly to rice.

(1) In the tables of Area and Yield of 'The Estimates' corrected figures might be given for the previous nine years for which accurate data have become available

For example in the introductory note to 'The Estimates' it is stated that "the tables of this volume are compiled from the data given in the final forecasts" with a footnote to the effect that 'the final forecasts figures are subsequently revised when finally adjusted figures are available and these adjusted figures are utilised as far as practicable'. But in a good many instances statistics of past years published in 'The Estimates' are found to differ widely from those appearing in the 'Agricultural Statistics'. This will be clear from the following table .—

Area under rice (thousand acres)

Year.	United Provinces. From "The Estimates" for 1935-36	United Provinces. From "Agricultural Statistics" for 1929-30 to 1934 35	Baroda State. From "The Estimates" for 1935-36	Baroda State. From "Agricultural Statistics" for 1929 30 to 1934-35.
1925-26	7,417	7,450	174	206
1926-27	7,437	7,471	194	223
1927-28	7,266	7,298	207	219
1928 29	7,024	7,057	201	200
1929-30	6,814	7,848	192	207
1930-31	6,722	8,844	212	260
1931 32	6,555	8,677	232	261
1932-33	6,140	6,262	226	238
1933-34	5,980	6,102	225	231
1934-35	6,437	6,559	228	223
1935-36	6,643	Not available	206	Not available.

It will be noted from the above table that the forecast figures are not revised in the light of the data published in the 'Agricultural Statistics'.

(2) The corrections incorporated in acreage should also be made in the total outturns This can be easily done with the help of the yield per acre figures which are published in the same publication ("The Estimates")

(3) The acreage and outturn of crops for those tracts for which forecasts are not prepared might also be included in the proper tables in order to make the all-India totals complete At present the statistics of the latest two years for such tracts are given in the introductory note, but as they do not appear in the proper tables, they are in most cases left out of consideration For example they are not included in the International Year Book of Agricultural Statistics. Another advantage of

forecast in the Bombay Presidency has found quite a number of ways in which even in a temporarily settled province areas are wrongly reported. These faults can easily be remedied if known. As regards standard yield, an important point insisted upon in one of the discussions by our own Statistician—Rao Bahadur M. Vaidyanathan—is the definition of the area to which a standard yield should apply. Such areas will differ in different provinces and from part to part of the same province and need not be simply revenue Districts as at present. The irrigated and unirrigated crops of the same kind will obviously need to have different standard yields. There is no reason, it seems to me, why the sampling survey for area and the standard yield crop cutting experiments should not be carried on by the same agency. As regards the seasonal factor, it seems to me that this has to be watched and recorded throughout the season by trained observers on the spot. The observer would again have to be the village officer but he ought to be given throughout the season postcards similar to those used by the honorary observers for the wheat survey in Canada carried out by the Winnipeg Free Press, so that as each month passed he could indicate clearly what factors had affected the crops and to what extent he thought the crop had been affected. What we need, then, it seems to me is—

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including them in the proper tables will be that they will be shown for 10 years instead of two.

(4) Regarding rice statistics the Punjab and the Madras States of Cochin, Pudukottai and Travancore might also be included in the tracts for which forecasts are prepared. Both of these areas are important producing units with about a million acres under rice in each. The Punjab is also important from the point of view of inter-Provincial trade It may be added that the two areas referred to produce more rice than any one of the seven States or agencies at present included in the forecasts.

(5) The Central Provinces States which are included in the rice forecasts, and the statistics for which are published in 'The Estimates', might also be shown with due details in the 'Agricultural Statistics', as the latter publication is generally supposed to be more detailed and complete

(6) There are some tracts for which reliable data is not available, e.g., the Feudatory States in Bihar and Orissa. The statistics for these States are not included in the all-India totals although their rice acreage averaged about 3 2 million acres during the last ten years. However estimates for them are given in the foot notes to tables of Area and outturn in 'The Estimates' In so far as the statistics for none of the permanently settled areas can be regarded as reasonably reliable it is suggested that rice data for the Feudatory States in Bihar and Orissa might equally well be included in the regular tables and in the summary remarks included in the introductory note to each volume.

APPENDIX VII, A.

Notes on Subject III (A review of work on the improvement of bullock-drawn implements with suggestions for the future).

(NOTE BY N G CHARLEY, *Research Engineer, Agricultural Department, Madras*)

The earliest attempts at implement improvement seem to have been associated with the first Experiment Farms which were in existence in various Provinces before the advent of the Agricultural Departments, and appear to have consisted for the most part in the importation of the most popular forms of Western implements, with little or no regard to their suitability for Indian conditions. The Madras Government, for example, in 1864, ordered from England a "steam plough, steam harrows and cultivators, seed drills, horse hoes, threshing machines and winnowers, chaffcutters and water-lifts" for a Farm which was opened at Saidapet. But, except for a few iron ploughs of the more adaptable types which left some mark, the equipment was in no way fitted to the conditions of the country, and these early attempts were doomed to failure

On the establishment of the Agricultural Departments in the early eighties, efforts in the introduction of improved implements began to meet with some small but definite reward. Attention was directed chiefly to the plough, for it was observed that plough was, as it ever is, the essential implement to tillage, common, in some form or other, to all parts of India, and for the reason no doubt that the problem of the plough seemed capable of such a ready solution in the immediate substitution of the modern iron plough for the indigenous wooden one

The "Madras Mail" in 1884 remarked "Slowly but we hope surely the rude primitive implements with which the native ryot has been wont to scratch the surface of the soil, prior to planting it, are being discarded, and lighter and more effective machines are being introduced. Last year's Agricultural Exhibition at Madras did much good in this direction, and the result has been an extensive trade in the handy ploughs of which some specimens were exhibited Messrs Robertson & Benson, of the Government Farms, Saidapet, have many times attempted to teach native agriculturists that it would be to their advantage to substitute the Swedish plough for their old fashioned Indian implements These efforts have been, so far, fairly successful, and we were pleased to hear recently that, in consequence of the many orders for ploughs, the trade has been made over to Messrs Massey & Co, of the Napier Works, Madras The firm now employs about 300 men, and is preparing for the execution of large orders for ploughs and other improved agricultural implements in their new works There are already about 400 ploughs, manufactured during the year, at work in the Presidency"

This account is interesting not only as a reference to some of the very earliest progress in the introduction of improved types, but in its recording of what must be one of the first attempts, if not the very first, at organised manufacture in India of modern iron ploughs.

The Swedish plough referred to was one of a range of five iron mouldboard ploughs with short iron beam head wheel and double handles made by the Overums Brok Manufacturing Co, Sweden, and "selected for importation and distributed by Government of Madras" in 1832 Its price in Madras, was given as Rs 18 wholesale and Rs 21 8 0 retail, and it was described as "perhaps the cheapest and most efficient plough yet tried in Southern India" It was first imported to Madras in 1877 The four other patterns of the same make, ranging in retail price from Rs 27-8 0 to Rs 43, were all described as strong useful implements the last and largest of them being "well adapted for breaking up black cotton soil in Bellary district" In addition to these Swedish ploughs, many others were imported and tested on the Saidapet Farm including a large American plough imported about 1870 and "extremely serviceable for all sorts of rough and difficult work," various sizes and styles of ploughs with poles and short beams, by Ransomes, Head and Jefferies, ranging in price from Rs 10 to Rs 43 the iron parts of the smallest being available at Rs. 6-8-0 wholesale, and the "D" plough of Messrs. J. & F. Howard, Bedford, which could be made up in India for about Rs 20

In Bombay Presidency, we read in the Annual Report of the Director of Agriculture for the year 1883-84 that a "new plough was brought out by Mr. Stormont at Bhadgaon" and that "two of Massey's improved ploughs have been purchased by ryots. The Local Fund Board, Ratnagiri, have purchased several ploughs and other implements from Madras, Cawnpore, and elsewhere." In the Annual Report for 1884-85, that "Messrs. Massey & Co., of Madras, exhibited, at the Show, some of their ploughs which are the result of careful experiments on the Saidapet Farm in the direction of adapting English and other foreign ploughs to the circumstances of the country." "The cotton soil plough has since been used by Mr. Woodrow on the College of Science Farm at Poona and found a very useful implement. With three pairs of animals it broke up a furrow 7″ x 9″, but the black soil still adhered to the mouldboard, a defect I hoped to get rid of after the first ten acres but have not yet succeeded" "Three of Massey's Swedish ploughs were purchased by ryots of Ahmadnagar district At Nevasa two are regularly used for garden lands" Again in the report for 1885-86, we read that "The plough which Mr. Stormont made up at the works of Messrs. Ransomes, Head and Jefferies, and which has been named the "Bokra" after the farm, is found very useful I bought 12 during the year with spare parts The cost landed Bombay was Rs 30 a piece—a cost capable of great reduction if locally made The Bhavnagar and Gondul State School Farms have each taken one for experiment and so have the District Local Fund, Sholapur; four to Hyderabad, and the rest are used by the Bhadgaon Farm." "Mr. Woodrow has worked a large plough received from the Secretary of State of which the price is not known. It has a rotary mouldboard." This was probably the first disc plough in India

In Bengal, reference is made to an American plough, modified under the directions of Mr. Weekes, Collector of Purnia. who states, "This is a very effective and light plough. I have had it made with one handle, two handles being an insufferable difficulty with natives It is constructed in pieces so that any piece worn out can be renewed."

These and many similar references to be found in the early records of the various provinces, mark what I think must be regarded as the first important steps in the march of implement improvement.

The Introduction of the modern all iron mould board plough might be regarded as a revolutionary change rather than an improvement in the strict sense of the word, and so indeed it was There seems to have been no marked evolutionary stage between the old form and the new, though there are many early references to "improved country ploughs" with crude Iron shares or mould boards stuck on in some fashion to the wooden plough body. Such notions long persisted in the minds of inventors and there are not a few who harbour them to day But the change had been made with little resort to intermediate forms and became more firmly established from year to year.

Though ploughs came in for most attention, it was apparent that other indigenous implements like blade harrows, cultivators and seed drills, were much in need of improvement or replacement by something better, and in each case, as with the plough, the situation was met by the importation of the latest type of Western implement. Thus we see the early Farms and Experiment Stations equipped with such implements as Cambridge rollers, wheeled cultivators, disc harrows, large seed drills, and other heavy and expensive horse-drawn implements That the early authorities ever believed that such implements might eventually be imported or made in the country and pressed on to the farmer, it is hard to imagine, though it would almost appear so for the practice of importing them persisted for many years The intention may have been to experiment with a view to the modification of the designs to fit local conditions, or more likely, I think, for the pursuit of better farming on the Government Farms, improved Implements of some kind were found essential, and these were the most readily available There is no doubt they were capable of doing good work But, whatever the idea, it is certain that such implements were quite unfitted to the requirements of the Indian farmer As an Indian writer caustically remarked: "The attempts to introduce any of them into general adoption proved a failure, and beyond a few dilapidated relics on Government Farms, there is little left to remind us of these attempts The idea was to work from the top downwards, to have a Central Farm, train English educated Indians, and hope that enlightenment would travel into the interior to the village ryot, an idea which is luckily going to the scrap heap in the way of these venerable implements."

On the reorganization and expansion of the departments in 1905, progress in the introduction of improved implements was greatly accelerated, though the path of progress continued to be marked with little else than iron ploughs Ransomes' turnwrest ploughs were amongst the first to become really popular particularly in the Deccan districts of Bombay. These were followed in various parts of India by the "Sabul," the "Monsoon" and "Jat", and other well known types by the same makers, popular types by other English and American makers, and similar productions of Indian manufacture by Messrs Kirloskar Brothers, Burn & Company, and later by Messrs Cooper Engineering Works, of Satara Stocks of ploughs were taken into the depots of the Agricultural Departments and held on consignment for sale to farmers Demonstration of implements became one of the regular items in the programme of district work

Agricultural engineers were appointed in a few of the Provinces, but whatever their achievements in other directions, I think it is not unfair to say that they wrought little improvement in the implements and machines of tha country. Though it was intended, no doubt, that their attention should be directed to the study and improvement of implements, I believe I am right in saying that, in most cases their activities were associated principally with pumping and boring and that much of their time was devoted to matters connected with the maintenance of elaborate Western implements and farmyard machinery, water supply and dairy plants, the construction of roads and buildings, and general estate work. They were burdened with many jobs outside their intended province, and most of them, no doubt, were without proper facilities for research on implements Whatever tha reasons, it is certain that the implement problem was not tackled from the right angle, that is from the bottom upwards working from elementary forms towards modern standards, taking care to preserve such essential fundamental qualities as lightness of draught, simplicity, robustness and low cost This is not to say that radical changes in design are not permissible They are permissible and a solution of some of the implement problems may demand them—the mouldboard inversion plough is an example—but they must be applied with caution and a full understanding of the conditions to which they must be adapted

With all the shortcomings, however, tha labours of the early workers on implements were by no means wholly in vain Over a long period, with many handicaps, they laid a rough foundation which has been of great valua to those who hava followed If there is one thing that has been brought home to present day workers, it is the futility of attempting to foist standard Western implements on to the country without a large measure of modification to adapt and fit them to the very different conditions of its agriculture, though there ara perhaps one or two exceptions

Little advance was made with cultivators, harrows, rollers, drills, ridging ploughs, scoops and others, though many sizes and types were imported over a period of many years A few in each of these types were imported annually by the various agents and sold to large land owners and to the Agricultural and Military Departments for use on their farms But, in their Western forms they were unsuited to Indian conditions, and little could be done to adapt them and bring them within the reach of the average farmer Some types, of course, he had managed to do without for centuries, and the functions of the others were served sufficiently well for his crude purpose by the two or three of his own indigenous implements So, tha prospect of inducing him to adopt additional types was never a bright one, as indeed it remains to day This brings us to the question of single or multiple purpose implements on which I have something to say further on

There were a few simple designs of cultivators and harrows evolved in the country by those who better understood the conditions and requirements and approached the problem from the right angle, and several primitive implements were imported for study from other countries, but they never attained any real popularity. So, we must be content, I think, to measure the progress of the past almost wholly in terms of improved ploughs A variety of sorts and sizes were developed to meet the requirements of the different tracts, and sales of imported and local makes, in all Provinces rose to a total of many thousands annually

In assessing the value of past labours in the field of implement improvement, much of the credit must be given to overseas agricultural engineers, and particularly to one or two enterprising English firms who have from time to time gone to great pains and expense in their attempts to cater for Indian requirements Considering their remoteness from the field of operations, their lack of first hand knowledge of conditions and other disadvantages at which they have had to work, they hava

done a valuable service and have deserved a reward which I imagine has never come to them. Many have been the types and designs expressly developed for Indian conditions, and if only a very few of them have hit the mark, we are able to appreciate the difficulty of the task and have learnt much of value from the failures. For what success they have achieved, of course, they are indebted in no small measure to the men of the Agricultural Departments and other services in India who have given them invaluable assistance by their knowledge of local conditions and requirements.

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AN APPRECIATION OF THE PRESENT POSITION.

Turning now to the present, which may be assumed to embrace the last few years, the situation, I should say, is characterised by a somewhat greater appreciation in all quarters of the importance of agricultural engineering to Indian agriculture, and a better attention to the subject on the part of Agricultural Departments, by the services of the Imperial Council of Agricultural Research in various directions, and by the marked improvement in the quality and prestige of Indian made implements, all attributable in some way to the valuable recommendations of the Royal Commission of 1926 These are all most welcome changes and I think the outlook for the future is brighter than it has ever been but the path of progress is still beset with many difficulties.

The more one studies the indigenous implements, the more one has to admire their primitive perfection born, no doubt, of many centuries of development, and considering the crude conditions under which they are required to operate, how wonderfully well they serve. And the more one realises how deeply rooted they have become in the lives and practices of the farmers and how very difficult to displace them. The real problem for the agricultural engineer in this country is not one of design and manufacture; it is one of capacity and cost There are no implements that could not be devised to do the jobs of the Indian farmer provided he had the cattle to work them, the means to buy them, and the conditions to permit of their economical employment. But his cattle power is so feeble, his purchasing power so low, his fields so small and ill arranged, and his intensity of production so terribly depressed, that, in the design and manufacture of implements for him, essentials have to be sacrificed to meet such conditions What chance is there of his using a 9 inch plough that would really work his soil and what chance of his affording good quality wear resistant steels? The design of modern implements to suit his conditions and his purse is a compromise in all directions and therein lies the extreme difficulty of it. The task of the agricultural engineer in India is to make one part serve where two served before. In advanced agricultural countries his task is hedged about by no such considerations and is relatively simple. I refer, of course, to the vast number of average and subaverage farmers. Fortunately we have our tracts where higher standards prevail and conditions are far more favourable to progress.

I believe that the modern revolution in agriculture in Western countries has been due more to new implements and methods of tillage than to any other single factor. It is probably no exaggeration to say that a revolution could be wrought in Indian agriculture by the wholesale adoption of improved implements, but we have no hope of attaining this goal or even distantly approaching it until we can effect a vast improvement in our draught cattle and in our soils. This is the brick wall we are up against; the rest of the implement problem is relatively simple of solution Just as most engines have a particular speed at which they run most smoothly and economically, so most implements have a particular size at which they do their best work. We are so much below this optimum size in the great majority of our ploughs and other implements on account of our wretched draught animals that we are deriving only a small fraction of the benefit that modern implements are able to confer. In the case of the smallest iron ploughs that are being sold to the farmer, it is highly questionable whether they present any advantage

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an implement which comes very close to fitting our requirements. Its popularity in certain parts is thwarted mainly by its first cost, and, if its price can be reduced to a suitable level by cheap mass production, we can make it play a leading part amongst the secondary implements of tillage. If not, we must continue to proceed by the method of compromise, by the more gradual process of development from indigenous forms. This brings us to the question of cheap local production to which I shall refer later.

The preparation of paddy lands presents another opportunity for improved implements. Amongst the puddling implements which include the wooden plough, several wooden rake-like devices, and the Burmese settuns or blade rollers, the latter employ the more modern principle and are conspicuous for their efficient operation, contributing in large measure to Burma's low cost of paddy production. We are endeavouring to improve these implements and adapt them to Madras conditions.

Perhaps the most admirable of the indigenous implements are the seed drills. Here we are striving to eliminate some of the human element by the incorporation of a simple mechanical seeding device which will replace the present hand feeding and give a more uniform and economical distribution of seed. Improvements in the drill itself are also being attempted. Many seed distributors and drills have been evolved in the various Provinces and, though the problem is a particularly difficult one, I am confident we are approaching a really satisfactory solution.

Other implements under improvement are the threshing rollers used in various parts of India, and heavy blade harrows for the lifting of groundnuts. Improved designs have been produced in both types and are under demonstration.

Reverting to ploughs, it is safe to say that progress is being made in all Provinces. The principal Indian manufacturers have attained a higher standard in their ploughs in recent years and are able to offer a wide range of sizes and styles to suit most conditions. Their prices on the whole are reasonable. A great deal of work has been done by the Agricultural Departments in the selecting, testing, and adaptation of ploughs to suit local conditions, and most of the ploughs made in the country have been produced at the instance of some agricultural department. Imported makes, on the whole, are no longer able to compete in price and value and are disappearing. So much for the principal types of implements in common use.

Then there are such types of implements as spring tooth cultivators and disc harrows, clod crushing and compacting rollers, rotary hoes or cultivators, ridging ploughs, subsoiling ploughs, earth scoops, and others which the Indian farmer knows little or nothing about. He has managed to do without them, making his few indigenous implements serve all his needs, but he could use these modern efficient types to advantage if they were adapted to his conditions and made available at the lowest possible rates. Many attempts have been made to adapt them and bring them within the reach of the average farmer and, though most have failed for reasons chiefly of cost, progress has been achieved in the development of simple cheap designs in some types. Light steel ridge ploughs and earth scoops of modern and efficient design are now available from Indian makers at a cost of Rs 10. Small spring tooth cultivators might be adapted to Indian conditions with little difficulty and used with good effect, but prices will preclude any wide scale adoption until they can be produced very cheaply by large scale production. The same may be said of rollers, disc harrows, and rotary hoes though here the problems of adaptation and cost reduction are more difficult of solution. Meanwhile, we can expect very little demand for all these types, and progress in their introduction can only be extremely slow.

Simple reaping or heading machines for jowar and wheat, a cotton planter which will deal successfully with the untreated fuzzy seed, a paddy transplanter, a stone gathering rake for the clearing of stony fields, and a light reversible disc plough, are other problems that might well repay much study and experiment. Some of them have been attempted but without success. If we study local practices, we see the need for many new bullock-drawn implements. A bund forming implement has been designed to replace the laborious and costly hand tool method of bunding. In addition to the bunding of fields for irrigation, it has found a valuable application in dry farming tracts for moisture conservation work. Another implement that might be devised with advantage for our dry areas is a bullock-drawn basin furrower on the principle of the new American damming lister. Dry farming, more than any other system of agriculture, is dependent for its success on proper implements, and presents a splendid opportunity for the implement designer.

But here a note of caution might be sounded In the recent competition inaugurated by the Imperial Council of Agricultural Research for improvements in tillage implements, the designs submitted displayed a marked tendency to depart too far from conventional lines into the realm of fantastic, impracticable, and gadget features. There is a distinct tendency, too, it would appear from what I have seen in India in the last 10 years, to strive for patentable ideas rather than workable useful ones. Those who give thought to the improvement of implements and machines should disillusion their minds that there is of necessity any merit in patentable features They are easy to conceive; in the vast majority of cases they are of no practical value whatever In the design of implements, the guiding principles should be extreme simplicity, complete practicability, and as far as possible conventionality and standard, well approved practice In manufacture the pressing need is for improved quality and finish, standardisation and mass production.

I refer to the question of single or multiple purpose implements. It is rarely that more than one purpose can be served efficiently in a single implement, and, as a principle, I am strongly in favour of the single purpose implement I fully realize, however, the desirability of restricting the ryot's assortment of implements to an absolute minimum consistent with the efficient execution of his work, and I accept that it might be advisable and even essential under certain conditions in this country to design an implement or machine for a dual purpose. But I would strongly advise that such a principle be applied with the utmost caution The same remarks apply to accessories These should be limited as far as possible, and anything in the nature of gadgets should be strongly discouraged as abominations.

In the operation of bullock-drawn implements, we have to contend with a difficulty which is inherent in the system of yoking and hitching Pulled as our implements are from the tops of the animals' necks, and close hitched to allow the driver control over his team, there is set up a steep line of draught which we can do little or nothing to rectify. Every force is resolvable into two component forces at right angles Thus the pull in the direction of the line of draught may be split up into a horizontal and vertical component, and, with our line of draught as steep as it is, the latter component assumes objectionable proportions It is this latter component that tends to lift our ploughs and other penetrating implements out of the ground, and is responsible for so much of our poor plough performance. We are all familiar with the sight of a plough ripping along on its share point in its attempt to keep in the ground, and with mouldboard and landside well in the air and largely inoperative It is all attributable to this steep line of draught We cannot lower the point of power application with our present system of yoking, we can reduce the gradient of the line of draught only by lengthening the hitch, but not to any appreciable extent for we must keep the implement well forward to give the driver control of his cattle, and for close working of corners and headlands in tiny fields

And now if we study a plan view of the same line of draught, we see, in the case of the plough, that it does not lie over the furrow but strikes off at a very appreciable angle This is due to the practice of wide yoking One animal must walk in the furrow; with the other yoked wide, the mid point on the yoke is far displaced from its correct position over the edge of the furrow This gives rise to a side draught or a side component of the pull which tends to draw the plough out of its correct position and too far into the land a tendency which is resisted by the ploughman's artifice of leaning the implement over towards the land with a consequence that the mouldboard is raised out of its true position relative to the furrow sole and rendered largely ineffective Though small degrees of displacement may be compromised by the off-setting of the pole, which corresponds to clevis adjustment on the short beam plough, there is no true remedy for this trouble save the close yoking of the animals, a practice which the farmer, unfortunately, is most reluctant to adopt

No reference to bullock draught would be complete without a word on yokes. There has been no lack of attempts to devise a yoke or a system of yoking that would be an improvement on the present primitive type Attempts have been directed principally to the elimination of sore necks by the provision of swept portions in the yoke where it contacts with the neck, and various forms of neck pads, and provision has usually been made also for adjustment of the neck portions as well as variable spacing between the animals But, so far, the designs I have seen have been much too elaborate and totally impracticable For the working of a single animal an inverted "U" shaped wooden yoke, which is fitted over the

neck and approximates to a collar has been devised, but the simplest and best arrangement of this type is no doubt the single leather harness, a very simple and effective device which consists essentially of a broad leather pad which fits over the neck and against the hump, and a pair of traces which are coupled to the implement through a small wooden spreader bar or swingle tree immediately behind the animal. *Such a device has long been used by the Department in Madras for the pulling of cultivators by single animals and recently it has been applied with good results to the yoking of a pair of animals in operation of Persian wheel water lifts, canemills, etc., each animal being provided with the single harness, and the four traces being connected to a common swingle bar at the rear.* But the ordinary country yoke with all its faults has such weighty advantages in its simplicity and low cost that *the difficulty of displacing it would be* difficult to overrate.

The distribution and sale of implements is still effected for the most part through the agency of the Agricultural Departments, though the leading Indian manufacturers are making some attempt to appoint their own agents or establish their own branches in the better sale centres. Demonstration is conducted by the Departments on much the same system as ever, with much room for improvement, I think, in the actual technique. The demonstration and sale of implements is pursued to some extent by agricultural, development and co-operative associations in the various *Provinces*, but *on the whole, as yet with no marked effect*. In Madras, as probably elsewhere, the purchase of implements is being assisted by the grant of takkavi loans, but the system as it is worked is open to many objections. Those, in the end, who are reckoned as fit subjects for a loan are those who least *require it*.

In viewing the progress in the introduction of improved implements it is difficult not to despair at times when we consider how little we have touched the vast population of *farmers. With all new types of implements with which the farmer is* not familiar, and even indeed with all improved designs we may offer him in his own indigenous forms, however *perfectly they may be adapted* to his conditions, we are confronted with tremendous obstacles in his extreme poverty and conservatism when we come to ask him *to adopt them. To put us more at a loss, we have* so little to lure him. In most cases it must be confessed, we are able to claim only a slender advantage for our new or improved design, and too often we are unable to show it. More often than not the *farmer is merely a tenant* whose insecurity *of tenure* and miserable reward for his labours deter all thought of improvement. The absentee landlord takes *so little interest* in his lands that we can expect no assistance from him. He is the chief offender. It is he who could do so much to forward the introduction of improved implements. So, we are left to look for our converts amongst the sprinkling of upper class farmers with some progressive instinct, with some appreciation of better implements and sufficient means to buy them.

There is a vast amount of assistance that can be rendered by the large landowners, co-operative, agricultural and other associations, and this must be organized. And, taking a longer view, our problem, as we have seen, is bound up with those of the improvement of draught cattle and soils, the use of manures, the consolidation of holdings, and others. But for our own part we must, by all means, improve our demonstration of implements and our propaganda; we must, by some means, engineer a reduction in the cost of implements to a point at which they may be employed *economically on farms* of average acreage and at which the average farmer is able to buy. And all the time, of course, we must strive for simpler and better designs.

APPENDIX VII, B.

Introduction of improved ploughs in India.

(NIZAMUDDEEN HYDER, *Director of Agriculture, H. E. H. the Nizam's Dominions*).

The Royal Commission on Agriculture in India, while reviewing the progress in the introduction of improved agricultural implements, remarked "The agricultural departments have, however, so far done disappointingly little in this direction. The sales of improved implements through departmental agencies are infinitesimal compared with the total number of implements in use in India, as is shown by the fact that, in spite of the large number of types of improved ploughs which have been placed on the market, only about 17,000 were sold in 1925 26 The total number of ploughs in use in British India in 1925-26 is given in the *Agricultural Statistics in India* as nearly 25 millions. Even if full allowance is made for the extent to which departmental sales are supplemented by private enterprise we cannot but feel that the agricultural departments have hardly made the fullest use of the opportunities which have presented themselves in this field." In this note it is proposed to discuss the introduction of improved ploughs only, which the Royal Commission has quoted as an instance.

2. The number of improved ploughs sold through departmental agency in 1925-26 was about 17,000 In the following few years the number increased to about 30,000, but in recent years it has gone down to about 19 000 This fall may to some extent be due to the general economic depression. but even 20.000 is a very small number, considering that plough is an implement which is required by every cultivator. Ever since the Agricultural departments came into being in India, they have been trying to introduce the improved ploughs, but the country plough still holds the field, and the improved ploughs are seen very few in number in the country side In the following are shown the numbers of ploughs. cane mills and fodder cutters sold in India through departmental agency in the years 1930-31. 1931 32 and 1932-33 (*vide* "Review of Agricultural Operations in India", 1931-32 and 1932 33) :—

	1930-31	1931-32	1932-33
Ploughs	27,170	19,200	18,756
Cane mills . . .	5,843	6,767	6,471
Fodder cutters	12,789	7,910	20,204

Fodder cutters are the most popular in the Punjab. The numbers of ploughs and *fodder cutters sold in that province in the same years were as follows* :—

	1930-31	1931-32	1932-33
Ploughs	9,434	8,500	5,990
Fodder cutters	12,570	7,700	19,550

The total number of ploughs sold in the 3 years was 23,924, while the total number of fodder cutters sold during the same period was 39,820 Many more fodder cutters have actually been sold in the Punjab than ploughs

3. From the above, it is clear that the iron plough of the modern type has not become sufficiently popular, even after 50 or 40 years of continuous propaganda. What is the reason? The Royal Commission has said in its report "An important obstacle is the natural dislike which the normal individual has to being regarded an eccentric because he has bought a novel implement " Is the cultivator, still so shy, who is growing the new improved varieties of crops on an area of about a crore and sixteen lacs acres (*vide* Review of Agricultural Operations) and who is buying about twenty thousand fodder cutters in a year? Another obstacle mentioned by the Royal Commission is the difficulty of finance Cannot the cultivator afford to spend ten or twelve rupees once in several years to buy one of the lighter kinds of ploughs? Many of the growers of the improved varieties of crops spend more than this for obtaining the improved seed every year Are all the buyers of about 20,000 fodder cutters and of about 7,000 cane mills of 1932 33 using improved ploughs? An enquiry on this point will give very useful information because these implements are far more costly than ploughs Another difficulty mentioned by the Royal Commission is the lack of facilities for repairs and for obtaining spare parts The iron plough does not require much repairs There is nothing in it which would break and require joining. The only wooden attachment is the beam in the lighter kinds of ploughs, which can be made

Interest on capital, depreciation and cost of repairs on implements, has not been taken into consideration, so the following additional sums must be debited to the ploughed plots in order to render the figures strictly comparative—

	Per acre.
Wheat	As. 7·7
Toria	As. 5·1
Cotton	As. 5·1
Average	As. 5·96

When the additional cost of the improved implements is deducted from the profits shown in Col. 5, there is *no apparent financial gain from their use* except in the case of the Set C plots.

Economy in time and labour.

The use of improved implements has in all cases resulted in a considerable saving of time and labour as the following figures show :—

—	Wheat				Toria				Cotton			
	Hours of labour saved				Hours of labours saved				Hours of labour saved			
	Man labour		*Bullock labour*		*Man labour*		*Bullock labour*		*Man labour*		*Bullock labour*	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Set A . .	19·6	20·7	19·6	20·7	14·0	30·6	14·0	30·6	11·2	24·6	11·2	24·6
Set B . .	14·9	21·7	14·9	21·7	12·1	21·1	12·1	21·1	10·6	19·6	10·6	19·6
Set C . .	8·6	13·3	8·6	13·3	6·9	15·3	6·9	15·3	2·6	6·9	2·6	6·9

The average saving in time and labour amounts to about 20 per cent.

Effect of Improved Implements on yield.

Detailed yields are given in the appended statement; those pertaining to each crop are discussed separately below :—

Wheat.—In Set A where an *equal number of operations has been performed* with indigenous and improved implements the yields are practically the same.

In Set B the use of improved implements has increased yields by approximately one maund of grain and two maunds of straw per acre.

In Set C improved implements have increased yields by approximately two maunds of grain and four maunds of straw per acre.

Toria.—In this case there is no significant difference between the yields obtained from plots under the various treatments.

Cotton.—In *Sets A and B the cultivated plots have given higher yields* by approximately 6 and 10 per cent. respectively.

In Set C the use of improved implements and line sowing has given an average increase in *yield of 1½ maunds per acre.*

General Observations.—The inference to be drawn from the experiment at the present stage seems to be that in a dry climate like that prevailing at Lyallpur where weeds are *easily kept in check furrow-turning ploughs and improved implements are not* required to the same extent as in areas of heavier rainfall or where weeds are more abundant. The use of improved implements, however, results in deeper, better and cleaner cultivation and in a 20 per cent. saving in time and labour.

The work already done merely serves to emphasise the necessity of making a much wider study of the subject in different parts of the country under varying conditions.

Statement I.

Year.	Set.	Wheat, toria, cotton — Yield per acre in maunds. Ploughed plots.	Cultivated plots.	S. E. in maunds.	C. D. at 5 per cent. level.	Remarks. Significant or Insignificant.
			Wheat.			
1930-31	A	22·22	23·27	0·83	2·66	Insignificant.
	B	22·42	21·17	0·48	1·54	Do.
	C	18·15	17·76	1·07	3·40	Do.
1931-32	A	14·00	13·92	1·3	4·12	Do.
	B	20·85	20·37	0·47	1·5	Do.
	C	19·05	17·98	0·88	2·83	Do.
1933-34	A	34·20	31·26	2 07	6·6	Do.
	B	32·96	32·21	1·66	5·29	Do.
	C	13·30	9·25	1·70	5·40	Do.
1934-35	A	31·73	33 35	1·3	4·15	Do.
	B	33·20	31·80	0·88	2·8	Do.
	C	27·61	25·48	0·68	2·15	Significant.
			Toria.			
1931-32	A	9·62	10·20	0·36	1·14	Insignificant.
	B	9·20	9·05	0·33	1·06	Do.
	C	7·65	6·75	0·72	2·3	Do.
1932-33	A	5·92	5·55	0·73	2·35	Do.
	B	7·15	7·20	0·35	1·12	Do.
	C	7 85	7·83	0·69	2·21	Do.
1934-35	A	11 42	12 32	0 31	0·99	Do.
	B	7·78	9 52	1·27	4·03	Do.
	C	9·25	10·13	0·71	2·26	Do.
1935-36	A	0·60	8·60	2·4	7·66	Do.
	B	8·98	0·50	0·35	1·11	Do.
	C	9·57	10·12	0 28	0·88	Do.
			Cotton.			
1932-33	A	6·41	6·42	0·39	1·26	Insignificant.
	B	7·65	8·12	0·6	1·92	Do.
	C	6·14	6·10	0·17	0·55	Do.
1933-34	A	8·68	8·84	1·14	3·64	Do.
	B	9·32	10·35	0·22	0·71	Significant.
	C	10·78	8·75	0·117	0·37	Highly Significant.
1935-36	A	15 20	16 23	0·57	1·83	Insignificant.
	B	15·42	16·45	0·59	1·88	Do.
	C	16·05	11·10	0·82	2·6	Significant.
1936-37	A	9·45	10 82	1·02	3·26	Insignificant.
	B	10·52	11·92	0·24	0·78	Significant.
	C	9·77	10 80	0·65	2·09	Insignificant.

Statement II.

Averages.

—	Yield per acre: Grain	Yield per acre: Straw	Hours of man labour	Hours of bullock labour	Value of produce	Cost of preparatory tillage	Profit (+) or loss (—) in favour of improved implements
	M. S.	M. S.	Hrs.	Hrs.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Wheat.							
Set A.							
1. Cultivated	25 18	56 25	66·0	66·0	94 1 0	12 6 0	+4 3 3
2. Ploughed	25 21	57 17	46 4	46·4	94 9 3	8 11 0	
Set B.							
1. Cultivated	26 15	60 22	65·8	68 8	98 1 6	12 14 3	+6 5 9
2. Ploughed	27 14	62 22	53 9	53·9	101 10 3	10 1 3	
Set C.							
1. Zamindara practice.	17 24	41 4	64 5	64 5	65 10 0	12 1 6	+8 14 0
2. Improved implements.	19 23	45 12	55·9	55·9	72 14 6	10 7 3	
Toria.							
Set A.							
1. Cultivated	0 6	..	45 8	45·8	36 10 9	8 0 3	—0 4 6
2. Ploughed	8 17		31·8	31·8	33 12 3	5 15 3	
Set B.							
1. Cultivated	8 32	..	57·3	57·3	35 4 3	10 11 9	+0 1 9
2. Ploughed	8 11	..	45·2	45·2	33 2 0	8 7 9	
Set C.							
1. Zamindara practice.	8 28	..	45·0	45·0	34 13 6	8 7 0	+0 12 9
2. Improved implements.	8 23	..	38·1	35·1	34 5 3	7 2 0	
Cotton.							
Set A.							
1. Cultivated	10 23	..	45·5	45·5	84 10 6	8 8 6	—3 0 6
2. Ploughed	9 37	..	34·3	34·3	79 8 3	6 6 9	
Set B.							
1. Cultivated	11 28	..	54·0	54·0	93 11 9	10 2 0	—5 14 3
2. Ploughed	10 29	..	43·4	43·4	85 14 0	8 2 6	
Set C.							
1. Zamindara practice.	9 7	..	37·5	37·5	73 8 0	7 0 6	+12 8 9
2. Improved implements.	10 27	..	34·0	34·9	85 8 6	6 8 3	

REMARKS.—The produce has been valued as under :—

Wheat grain at Rs. 3 per maund.
Wheat straw at annas 5 per maund.
Toria at Rs. 4 per maund.
Cotton at Rs. 8 per maund.

The labour was valued as under :—

Hours of man labour at Re. 0-8-0 per 8 hours.
Hours of bullock labour at Re. 1 per 8 hours.

APPENDIX VII, D.

(*Note by* RAO SAHIB K. I THADANI, *Director of Agriculture, Sind*).

There is no great prospect of agricultural machinery, *e.g.*, tractors for ploughing, threshing machines etc., being used by the farmers in Sind and several other parts of India owing to the conditions of farming and land tenure system prevailing in these countries. Even the bullock drawn implements should be such as will not require any skill in adjusting them and should be simple in construction, cheap in cost, easily portable and can be manufactured and repaired locally and above all should not require greater draft than what the local pair of bullocks can draw or pull. Consequently, there is great limitation in the scope of improvement. The most important implement is the Indian plough which serves as a general purpose implement for the needs of the Indian farmer. It does not invert the soil and serves more as a cultivator. Considerable improvement however, has been made over the local plough and an Egyptian type of a plough called the 'Sarkar' plough has been introduced and has become very popular in the Barrage areas of Sind, and is the Standard plough in Thar Parkar District. This plough is made entirely of wood with a flat iron share attached to the body by a bolt and a nut The steel share enables the plough to penetrate the soil easily and being made of iron sustains wear and lasts for a long time The share is replaceable and can be changed when worn out by use. This plough has a cheap and simple wooden attachment with which the plough can be utilised for ridging operations. The price of this plough is Rs 4/8 only This implement saves much time and labour and also gives better tilth than ordinary plough Such wooden ploughs are not useful for deep ploughing and stir the surface to a small depth and are likely to produce a kind of a *hard pan in stiff textured soils*, which tends to restrict the root development and also interferes with soil drainage It is therefore most desirable that the Agricultural Engineers and other officers concerned should devise a plough which would penetrate deeply and at the same time could be drawn by a pair or two pairs of bullocks for occasional use to break the so called 'hard' pan or false bottom formed under the surface of the soil

Besides the wooden ploughs, some patterns of iron ploughs have also been introduced. These iron ploughs have a fixed mould board for inverting the soil and are more useful for work in dry soils as compared to soils which have been irrigated for ploughing with wooden ploughs like the Sircar plough described above which cannot be worked in 'dry' stiff soil The 'Hyderabad' and the 'Meston' ploughs have become popular The Hyderabad plough costs Rs 13/8 each

The other implement in common use is the 'Sanvar' or plank roller This implement is sometimes used for breaking clods but its chief use lies in pressing the surface of a ploughed field which had been irrigated before plough was used so that moisture may be retained and also it may provide a smooth seed bed for drilling operations. Several clod crushers drawn by bullocks have been tried but the initial cost is prohibitive A new type of a clod crusher known as the Jenkins' clod crusher has been designed by the Agricultural Department and its price is about Rs 70 Although a very useful implement its price is not within the reach of an ordinary farmer. This implement can also be used for threshing wheat Some improvement has been made in the local seed one-coultered drill by replacing the wooden bamboo tube with an iron tube. The three coultered Lyallpur seed drill has been found useful and is being introduced. The other improved implements designed by the Agricultural Department are the 'Cumming' bullock cart and the winnowing machine worked by hand, the prices being Rs. 150 each Further research is wanted in devising the following bullock drawn implements :—

(a) A suitable reaper or harvesting machine, bullock power, for harvesting the wheat crop, efficiently and economically

(b) An efficient threshing machine bullock power, for wheat, rice and other cereal and pulse crops

(c) An implement which can be utilised for (a) constructing small field bunds and (b) levelling uneven lands

(d) A universal seed drill, bullock power, which can be adopted for the sowing of all main kharif and rabi crops

(e) An effective implement for cutting or uprooting cotton stalks

(f) A portable machine for the purpose of applying insecticides, sprays, washes and dusts to fruit orchards and to field crops

The primary aim in the design of these improved implements should be to combine efficiency in work, simplicity in construction and cheapness in cost.

APPENDIX VII, E.

Agricultural implements.

(SARDAR DARSHAN SINGH, I.A.S., *Deputy Director of Agriculture, Gurdaspur*).

Agricultural implements in use in the Punjab are, on the whole, well adapted to local conditions. They are within the capacity of the draught oxen, comparatively inexpensive, light and portable easily made, and what is even of greater importance, are easily repairable and they are constructed of materials which can be easily obtained. *Inspite of these advantages, there is undoubtedly very great scope for improvement in* the light of modern knowledge of soil conditions So far, very little has been done in this direction, which is evident from the fact that inspite of there being so many improved types of ploughs in the market the sale through Departmental agencies is very small as compared with the total number of ploughs in use Even if full allowance is made for the extent to which Departmental sales are supplemented by private enterprise, one cannot but feel, that the furrow turning ploughs have not made their way to the zamindars home for one reason or the other Certainly, there are difficulties which have to be faced in pushing the use of improved implements and of improved agricultural machinery generally. There are difficulties of finance Certain kinds of agricultural machinery such as tractors, power mills for crushing sugarcane and threshing machines are obviously entirely out of the reach of small cultivators unless some system of using them co-operatively can be devised. But while the financial difficulty may sometimes go against the adoption of improved types of even comparatively inexpensive implements such as ploughs and hoes, the natural dislike which the average individual has to being regarded an eccentric on account of having purchased a new implement is also an important obstacle The remedy for this is simple and effective. Propaganda must always be intensive, that is, it must not rest content with trying to convert one or two individuals in a village here and one or two in a village there, but it must reach all the cultivators of a village and induce as many of them as possible to accept the improvement In so far as cost is a deterrent to the adoption of even comparatively inexpensive implements, the Department would do well to consider the possibilities of mass production of the wooden parts of such implements with a view to bring down the cost. The Department may moreover stock the spare parts with the Agricultural Assistants, so that the same may be readily and easily available to the cultivators. One of the main reasons as to why the improved bullock drawn implements such as ploughs, hoes, etc. do not find a large sale, is, that their spare parts are not readily available. There are also difficulties arising out of lack of facilities for repairs. But even after giving due regard to these handicaps and disabilities, it is impossible to avoid the conclusion, that the Department is far from being in as strong a position to help the cultivators in regard to the implements which are within his means as it is in regard to improved seeds.

There is a very wide field of research awaiting the worker on agricultural implements A fundamental problem which has still to be tackled is, the relation of the capacity of the cultivators' bullocks to the implements they are required to draw. The construction of the ordinary country plough is such, that it does not invert the soil but his plough is the best that he can use with the bullocks he possesses Moreover it is believed that the importance of conserving moisture has been the principal reason for the Indian cultivator's preference for the type of plough used by him; and as he is too poor to afford a variety of implements, the ordinary Indian plough is the best type for a general purpose implement suited to his needs. It is often worked not as a plough, but as a cultivator. It is obvious, however, that notwithstanding the great diversity of local conditions, a country such as India, presents great possibilities of advance in this direction. It should be emphasized on the workers entrusted with the work of effecting improvement in implements, that the aim should be the evolution of a small number of types, suitable for a wide range of conditions, low in cost and within the means of small cultivators. Such implements will thus be suitable for mass production as well. The improvement of existing agricultural implements offers a more promising field for the activities of the workers than the introduction of new implements.

APPENDIX VII, F.

(Note by S. HARCHAND SINGH, L.A.G., *Deputy Director of Agriculture, Patiala State*).

It has been observed from practical experience that the cultivator class is very conservative by nature especially in replacing primitive type of ploughs by improved inverting ploughs, the reason is that usually there are several nuts and bolts, the handling of which a cultivator or the village blacksmith feels to be out of his capacity, the spares are not available easily and these ploughs are usually costly ones.

Some years back an Agricultural and Industrial Exhibition was held on a very large scale in Patiala and this point was thought over. The opinion of the Engineers and Agricultural Experts was sought. After long deliberations the problem was solved. The main points kept in view were that the bullocks of the cultivators are accustomed to the use of Desi plough and it was necessary that the new Inverting Plough should work on the principle of Desi plough and the village blacksmith and carpenter should be able to repair it just like local implement for which the farmer has to pay him in kind at every six monthly harvests for their repairs.

A very simple Inverting Plough was invented, which is very cheap as compared with other Inverting Iron Ploughs. There is not a single nut or bolt in it; village carpenter and blacksmith can repair it, does not require any spares and works like a Desi plough in which bullocks do not feel any inconvenience and in actual working it is like an Inverting Plough.

In case of Inverting Plough the tip, which usually wears out has been replaced by an iron rod (Phala) in this plough which can be sharpened by the village blacksmith just like a Phala of Desi Plough and beam can be prepared by a village carpenter as in case of Desi plough, the only part a cultivator has to add to it after purchase, for making it into workable condition.

Hence it is essential so as to increase the use of improved implements simple devices should be made which are cheap in price and can be repaired easily by the village carpenter and blacksmith.

APPENDIX VII, G.

Note on bullock cart wheels mounted on ball bearings.

(B. S. PATEL, N.D.D., N.D.A., I.A.S., *Live-stock Expert to the Government of Bombay,*

and

C. G. PARANJPE, *Agricultural Engineer to the Government of Bombay*)

The recent introduction of pneumatic rubber tyred wheels fitted on a special standard cart with the object of reducing the draft and carrying more load has given *rise to a serious thought on the subject.*

With all the advantages claimed for such a cart, there are many difficulties in the universal adoption of such a cart by an ordinary cultivator.

In view of this, three years ago one of the authors of this note Mr. B. S. Patel, Deputy Director of Agriculture, Gujarat, thought of introducing roller or ball bearing fittings for the wheels of the country cart, as he believed that most of the advantages claimed for the rubber tyred wheels would be secured by fitting improved bearing to the wheels of the country cart. With this idea he suggested to the other author of this note, Mr. C. G. Paranjpe, Agricultural Engineer to the Government of Bombay, to construct such wheels and try them out on the ordinary cart for finding out the advantages in the draft, such an arrangement would give, over the country cart and see how it compared with the pneumatic rubber tyred wheels.

With this object in view, Mr Paranjpe worked up the idea since 1935 by designing at first roller bearing fittings for the ordinary cart wheels which gave very encouraging results. Second attempt was made with ball bearings instead of roller bearings, as the roller bearings were found to be more expensive.

The roller bearings were first fitted up in a specially made housing which was also found to be unnecessary and expensive. The bearings now are fixed on a steel sleeve which is slipped over the axle and held in position by a suitable cotter pin. In the latest model the sleeve is used for the outer bearings only, the inner ones being put directly on the axle with increased diameter to obtain greater strength at the neck of the axle which is the weakest point.

Comparison for Draft and Utility.

Three types of cart wheels as described below were compared :—

1. An ordinary cart was fitted with ordinary wooden wheels. The diameter of the wheels is 4′ and the diameter of the hub is 10″. The wheel is fitted with iron rim and mounted in ordinary way on an iron bush. The tyre is 2″ wide. The weight of the cart is 10 cwts.
2. Another country cart was fitted with wheels described above but the wheels were mounted on the axle with ball bearings of latest design described above. The weight of the cart is 10 cwts.
3. A special cart fitted with rubber tyred wheels fitted on roller bearings. The diameter of the wheel is 2½′. The width of the tyre is 7″. The weight of the cart is 7 cwts.

It might be noted that the same country cart used under items 1 and 2 was fitted with rubber tyred wheels, the axle and the roller bearings used on a special cart. The weight of this cart is 9 cwts. The draft required is about the same as for the special cart fitted with rubber tyred wheels as could be seen from the statements.

The above three carts were loaded with different loads such as 3 men to 30 cwts.

The carts and the loads were drawn by a pair of bullocks on three kinds of roads, *viz.*, (*a*) hard level road, (*b*) steep metal road and (*c*) katcha murrum level road and the draft was taken with a dynamometer by means of a special contrivance. The results are given in the attached statements A, B and C. These statements show that the ordinary cart wheels fitted on ball bearings have an advantage over the ordinary wheels fitted with iron bushes in all cases and on the rubber tyred wheels fitted on roller bearings in the case of level concrete road only.

The draft on the metal road for a load of 10 cwts, which the common country cart is expected to carry, is as under :—

	Lbs.
Country cart wheels	80
Country wheels on ball bearings	60
Rubber tyred wheels on roller bearings	60

This shows that the ball bearing country wheels and the rubber tyred wheels need equal draft while the country cart wheels need the highest draft.

On a steep metal road, the draft for a load of 10 cwts is as follows —

	Lbs.
Country wheels	150
Country wheels fitted on ball bearings	120
Rubber tyred wheels fitted on roller bearings	130

Here also the ball bearing wheels need less draft than the country and the rubber tyred wheels by 20 per cent and 8 per cent respectively

On the katcha level murrum road covered with sand the draft of a load of 10 cwts is as under .—

	Lbs.
Country wheels	155
Country wheels fitted on ball bearings	110
Rubber tyred wheels fitted on roller bearings	100

STATEMENT (A).

Hard Level Road.

Load in the cart	Tar Road: Shop cart fitted with ordinary wheels weight 10 Cwts.	Tar Road: Shop cart fitted with ball bearing wheels weight 10 Cwts.	Tar Road: Rubber tyred wheel cart obtained from contractor weight 7 Cwts	Tar Road: Shop cart fitted with rubber tyred wheels weight 9 Cwts.	Metal Road: Shop cart with ordinary wheels weight 10 Cwt	Metal Road: Shop cart fitted with ball bearing wheels weight 10 Cwts.	Metal Road: Rubber tyred wheel cart obtained from contractor weight 7 Cwts.	Metal Road: Shop cart fitted with rubber tyred wheels weight 9 Cwts.
	Draft in lbs.				Draft in lbs.			
3 Men	30—60 / 45	20—40 / 30	15—40 / 27 5	15—40 / 27 5	30—70 / 50	30—40 / 35	25—40 / 32·5	20—45 / 32·5
3 Men and 5 Cwts.	40—80 / 60	30—50 / 40	25—65 / 45	35—50 / 42 5	40—100 / 70	35—60 / 47 5	35—60 / 47·5	30—70 / 50
3 Men and 10 Cwts.	50—110 / 80	35—70 / 52 5	30—85 / 57 5	35—75 / 55	60—100 / 80	40—80 / 60	40—80 / 60	40—85 / 62·5
3 Men and 15 Cwts.	65—140 / 102 5	40—80 / 60	40—100 / 70	40—100 / 70	70—120 / 95	50—100 / 75	55—100 / 77·5	60—95 / 77 5
3 Men and 20 Cwts.	80—180 / 130	60—100 / 80	60—110 / 85	60—110 / 85	80—140 / 110	60—120 / 90	70—120 / 95	80—120 / 100

Concrete road.

Load in the cart.	Shop cart fitted with ordinary wheels weight 10 Cwts.	Shop cart fitted with ball bearing wheels weight 10 Cwts.	Rubber tyred wheel cart obtained from the contractor weight 7 Cwts.	Shop cart fitted with rubber tyred wheels weight 9 Cwts.
		Draft in lbs.		
3 men . . .	15—45 / 30	10—20 / 15	10—25 / 17·5	10—25 / 17·5
3 men and 5 Cwts. .	20—60 / 40	10—35 / 22·5	20—40 / 30	20—40 / 30
3 Men and 10 Cwts. .	35—70 / 52·5	15—40 / 27·5	20—70 / 45	30—60 / 45
3 Men with 15 Cwts. .	40—90 / 65	20—45 / 32·5	35—85 / 60	40—75 / 57·5
3 Men with 20 Cwts. .	50—120 / 85	20—60 / 40	40—100 / 70	50—90 / 70

NOTE.—The top figures show the range of drafts in lbs. while the bottom figure gives the average.

STATEMENT (B).

Ascent on Metal Road.

Load in cart.	Shop cart fitted with ordinary wheels weight 10 Cwts.	Shop cart fitted with ball bearing wheels weight 10 Cwts.	Rubber tyred wheel cart obtained from the contractor weight 7 Cwts.	Shop cart fitted with rubber tyred wheels weight 9 Cwts.
		Draft	in lbs.	
3 Men	60—120 / 90	50—90 / 70	60—80 / 70	40—100 / 70
3 Men and 5 Cwts. .	70—160 / 115	60—120 / 90	80—115 / 97·5	80—125 / 102·5
3 Men and 10 Cwts. .	120—180 / 150	80—160 / 120	100—160 / 130	100—160 / 130
3 Men and 15 Cwts. .	140—240 / 190	120—190 / 155	130—190 / 160	140—185 / 162·5
3 Men and 20 Cwts. .	170—280 / 225	140—220 / 180	150—220 / 185	160—220 / 190

NOTE.—The top figures show the range of draft in lbs. while the bottom figure gives the average.

STATEMENT (C)

Kacha Murrum Road covered with Sand.

Load in cart.	Shop cart fitted with ordinary wheels weight 10 Cwts	Shop cart fitted with ball bearing wheels weight 10 Cwts.	Rubber tyred wheel cart obtained from the contractor weight 7 Cwts.	Shop cart fitted with rubber tyred wheels weight 9 Cwts.
		Draft	in lbs.	
3 Men	65—100 / 82·5	40—75 / 57·5	20—80 / 50	30—80 / 55
3 Men with 5 Cwts. .	90—150 / 120	60—100 / 80	45—100 / 72·5	60—100 / 80
3 Men and 10 Cwts. .	120—190 / 155	90—130 / 110	60—140 / 100	70—140 / 105
3 Men and 15 Cwts.	140—240 / 190	130—150 / 140	80—180 / 130	100—170 / 135
3 Men and 20 Cwts. .	170—290 / 230	160—180 / 170	110—200 / 155	120—200 / 160

NOTE.—The top figures show the range of draft in lbs. while the bottom figure gives the average.

APPENDIX VIII, A.

NOTES ON SUBJECT V. (A REVIEW OF THE WORK DONE ON WATER REQUIREMENTS OF CROP WITH SUGGESTIONS FOR THE FUTURE.)

(NOTE BY DR. R. D. REGE, *Crop Physiologist, Sugarcane Research Station, Bombay-Deccan, Padegaon.*)

The first systematic work on the water requirement of Indian crops has been done by Dr. Leather(1) and as these researches are a matter of common knowledge, it would be unnecessary to deal with them here. In the present review besides the information on the water requirement of important Indian crops, researches on such problems as the influence of the water table and the effect of irrigation on soil have been also incorporated.

(1) *Rice.*—In Bombay, Bengal and recently by Singh and his co-workers (2) in the Benares Hindu University, attempts have been made by pot culture experiments to determine the exact water requirement of the rice plant on dry weight basis. These experiments have demonstrated that the average transpiration ratio is about the same in all these centres. In Bombay the actual loss of water by transpiration during the complete life cycle of the plant has been shown to equal about 25 inches of rainfall while Singh and his co-workers (2) have calculated the exact water requirement of crop both for transpiration and evaporation to be 27·4 inches. These workers could get a normal growth and yield of crop by maintaining the moisture content at 20 to 21 per cent of the oven dried soil. This experimental evidence leads one thus to doubt the necessity of extremely wet conditions or submergence of the rice land during the part of the growth as is the usual practice among the cultivators. This has been recently carefully investigated by Sen (3) at the Calcutta University who has found that flooding the field after transplanting for about 3 weeks for early varieties and somewhat longer for late varieties followed by subsequent dewatering is beneficial to the plant. This temporary submergence of the land is specially beneficial to the growth of the tillers. Later on, however, a field with sufficient moisture but no water standing in it favours tillering while water definitely suppresses it. Standing water on the other hand increases the height of the plant and does not seem to affect the plant adversely. It is suggested that water produces and maintains a certain texture and temperature condition of the soil suitable for young seedlings during their earlier stages of growth. Subramanyium (4) maintains that swamp soils provide certain constituents which are not available in dry soil, one of these being silicon. He thinks that if the nature of these substances released during the swampy condition is determined, it may be possible to provide them to the plant in dry soil conditions. Bal,(5) on the other hand has shown by pot culture experimenments that in the heavy soil of Central Provinces, rice crop showed a better growth when not submerged in water. The behaviour of the medium soil has been of the same type though it is not of the same order.

A great deal of field experimental work has been carried out under irrigation in order to determine the duty of water for rice. In Madras because of the big differences in the soil, it is as low as fifty acres in Coimbatore, about seventy in Tanjore and nearly a hundred in Godavari. Further experiments are in progress with varying duties for rice in order to find out the correct requirement for the maximum outturn. In Sind, experiments conducted with different duties have shown that a duty of 45 was too little. 35 and 40 produced a good crop while 30 and under was found to be necessarily excessive. In Bengal, the amount of 40 inches total depth is held to be the minimum necessity for the successful crop of rice. In Mysore, experiments under tank irrigation for five years have shown that by doubling the supply of water only about 9 per cent. increase in yield has been obtained, showing that the same amount of water could be utilised for irrigating twice the area with profit. In Punjab, the Khal Kiari system of irrigation is expected to save about 25 per cent. of the water. Lowering of the transpiration rate of rice has been obtained in Bengal by manuring with phosphates and it is found that in years of deficient rainfall phosphates are particularly helpful in maturing a crop which would otherwise suffer from shortage of moisture.

Significant variation in the water requirement of the varieties has been observed by many workers. Singh and his co-workers (2) have shown this to be mainly due to the variation in the length of the age cycle. According to them efficient varieties seem to shorten their life cycle in order to cut short the use of water to a minimum. At Sabour it has been further observed that late varieties also require a higher

minimum moisture content in the soil for the successful growth than the medium or early varieties. Morphological studies showed that the cultures, which stood the drought best, had smaller epidermal cells.

As regards the periodic water requirement, Singh and his co-workers (2) have found three marked periods of high water requirement, the first during the seedling stage covering a period of about ten days, the second during the pre flowering stage covering about twenty five days and the third during the period when the grains are forming covering a space of five to seven days. The last period of critical water requirement extends over a small number of days and the cultivator will have to exercise his proper judgment to determine exactly this period and irrigate the crop at the opportune time

(2) *Wheat.*—Howard and Howard (6) have shown that in Quetta as far as irrigated wheat is concerned the cultivators apply from 30 to 50 per cent. excess water than its requirement and these increased number of irrigations generally lead to the decrease of yield by about 26 per cent. One or two irrigations have been found to be the optimum requirement Experiments at Shahajahanpur have shown that the number of irrigations required for the crop is dependent on the quantity of rainfall during later part of summer (September October) and during winter in December-January If this is sufficient and well distributed, the crop may not require any extra irrigation but in such seasons are rare, generally two irrigations with 60 000 gallons per irrigation have given the best yield It has been further found that reduction of the quantity of water below 60.000 gallons per irrigation is not conducive to good yields Much detailed work has been carried out at the Agricultural Research Station, Sakrand, in Sind, both as regards the total delta and its distribution as well as the amount necessary for initial soaking The results have definitely shown that the normal and optimum field duty for this crop is 200 Higher quantity of water does give increased yields, but this increase is not proportional to the extra water added On sweet lands 12 8 to 14 4 acre inches are sufficient to give normal yields while kalar lands require about 18" A varietal variation has been also observed, C PII 47 giving as much yield with 12 8" as Pusa 12 with 16 5". It has been further found that provided an adequate soaking dose for sowing purposes is given, the subsequent distribution of irrigational water has not got much effect on final yields Singh and his co-workers (2) have concluded by pot culture experiments that the minimum water requirement of wheat is only 8 5". The varietal differences are not well marked In Punjab, studies on irrigation frequency in relation to motling of wheat have shown that increased irrigation causes motling on poor sandy soils only and not on rich soils

A few comparative trials on the suitable varieties for irrigated and dry tracts have been carried out in the Central Provinces and Sind In the Central Provinces, P 100 is found to be the best under irrigation and Pusa for the ordinary condition of dry farming This province is also conducting investigation on the root system of all the varieties grown in the province which is expected to be of considerable importance for the selection of the varieties for the different conditions In Sind under "Bosi" cultivation, A T 38 and C PII 47 are high yielding while Pusa 12 has shown poor performance On the other hand Pusa 12 is found to be as good as C PII 47 under irrigation

(3) *Cotton*—At the instance of the Indian Central Cotton Committee, detailed investigations on the water requirement of cotton have been carried out at Lyallpur in Punjab and Sakrand in Sind Similar studies are also on hand at the Sugarcane Research Scheme, Padegaon

The Lyallpur experiments which have been conducted for nine years have definitely shown that increased yields could be obtained with heavier irrigations and that the fibre properties generally improve with irrigations It has been further found that the first irrigation should be given three to four weeks after sowing as the delaying of it definitely affects the yield while no irrigations are necessary after 15th of October for 4F cotton For late maturing cottons, however, later irrigations would be a necessity The water requirement of 4F approximates 24 to 28' and sowing on ridges or in flat is found not to in any way affect it The Sind Physiological investigations which have been conducted for similar long period have shown that while there is a lineae relationship between the quantities of water and yield, the barrage duty of 100 is considered to be the optimum as it is just sufficient for crop growth without materially leaving any residual water. It has been further found that the reduction of intervals between waterings at the flowering and fruiting

time, viz., August-September results in higher outturn of *Kapas* per acre. Detailed observations have shown that this increase in yield is due to a direct benefit from the treatment which increases the efficiency of the plant in fruit production. The field experiments conducted by the Sind Department of Agriculture has given a satisfactory yield on a delta varying from 39" to 27" including rain according to the date of sowing. The sowing season of the cotton crop extends from April to middle of June and the crop finishes off by the end of December. In Bombay, an experiment to test the efficacy of irrigations during July and August (the flowering period) at intervals of 10, 15 or 20 days on the yield and fibre quality has been conducted for three years at the Sugarcane Research Scheme, Padegaon, in comparison with the current method where one or two irrigations are given in July with no irrigations later All these treatments have given lower yields, there being a progressive fall in yield with the reduction of intervals between irrigations. This has defintely proved the existing system of irrigation to be the best for this tract. The testing of the samples of *Kapas* for the quality of staple by the Technological Laboratory, Matunga, showed no change due to treatments in the fibre properties Among the varieties, *Banilla* is considered to be efficient. In Madras, an irrigation experiment revealed that good crops of *Cambodia* cotton could be obtained by only two waterings applied after the monsoon and the last time of irrigation is in the second week of December or early in January According to Singh and his co-workers(2) the minimum water requirement of cotton is 28·3", there being a wide range in the varieties. Out of the sixteen varieties under experimentation, Cawnpore 520 is found to be the most efficient. Two critical periods of the water requirement have been observed, one during the seedling stage, covering about twenty days and the other during preflowering and flowering stages covering about thirty days

(4) *Sugarcane*—Before the starting of the Sugarcane Research Schemes in the different provinces by the Imperial Council of Agricultural Research, the only work of importance on the water requirement of sugarcane had been conducted at Shahajahanpur in U P and at Manjri and Hadapsar in the Bombay Presidency. This has supplied a very good basis for further investigations of the new research schemes in these provinces. Singh and his co-workers(2) have concluded from their pot culture experiments that the minimum water requirement of sugarcane is 45" They have found that the varieties of sugarcane differ more widely among themselves in their relative water requirements than those of cotton. Co. 205 has come out as the most efficient of all the varieties under experimentation The efficiency in the water requirement is found to be directly proportional to the yield inasmuch as the greatest efficiency corresponds to the maximum yield. Similar figure for the water requirement has been also obtained in Bihar by pot culture experiments. These researches have also confirmed the varietal variations At Shahajahanpur, in the physiological section subsidised by the Imperial Council of Agricultural Research, investigations in the inter-relationship of nitrogenous manuring, water duty and date of planting on the growth and yield of sugarcane are in progress. The present indications are that with low nitrogen in all sowing dates optimum yield is obtained with medium watering while with nitrogen at 100 lb per acre optimum returns are obtainable with considerably low water duty. The decreasing efficiency is observed of both nitrogen and water with delay in the time of planting. Agronomic trials on the interaction of nitrogen and water are also being conducted by the Department of Agriculture both at Shahajahanpur and Muzaffarnagar. The results have shown progressive increase with the corresponding increase in the number of irrigations, five or six irrigations being the optimum depending upon the season As regards the quantity of water per irrigation, 80,000 gallons per acre seems to give better results throughout as compared to 60,000 and 100,000 The practice of the cultivators to fill the field to the maximum at each irrigation is considered therefore very wasteful. Larger quantity of water is however found to bring in early maturity of the cane with increased per cent. sucrose. In Madras, experiments at the Anakapalle Research Station have conclusively proved that with Co 213 cane, provided the land received a deep cultivation and hoeing to start with, the number of irrigations could be reduced to one with better yields of *jaggery*, the number of irrigations usually given by the cultivators being 5 to 10

In the Deccan Canal tract, sugarcane is grown entirely on irrigation, the irrigational turns being about 33 to 50 depending upon the time of planting The problem of the judicious utilisation of water is therefore, very important and is being investigated in detail both by pot culture and field experiments at the Sugarcane Research Scheme, Padegaon, since its establishment in 1932 with the

subsidy from the Imperial Council of Agricultural Research. In the field experiments, accurately measured quantities of water are carried to the plots through home pipes thus entirely eliminating the loss by seepage. The three years' investigations on the January planted crop with the manurial treatment of 150 lbs. N applied as per Manjri standard method have definitely shown that the treatment of 70" including rainfall would fall short of the crop requirement under adverse climatic conditions while the optimum requirement for all the seasons for this manurial treatment is found to be 95". On the other hand in the quantities above 120" there is a definite lowering down of the physiological activities at later stages of plant growth resulting in the significant fall in yield. This is traced to the leaching down of nitrates and also to less utilisation of cake applied at earthing up time as a result of the slowing down of the microbiological activities of the soil with heavy doses of water. The interrelationship of water and manure is clearly brought out indicating the necessity of higher manuring with higher irrigation. From the standpoint of the quality of *gul*, however, higher waterings are found to be beneficial as these hasten the maturity resulting in the improved quality of juice. A better coloured *gul* with the reduction in the percentage of alkali salts is obtained in the treatment of 130" as compared to all the lower waterings.

It has been further inferred from the soil moisture studies that whatever may be the irrigational treatment, so far as it does not falls short of the soil saturation the water utilised by the crop in evo-transpiration is practically the same as it is controlled by the field water holding capacity of the soil. The efficiency in the water requirement of the crop for the different seasons is however found to be greatly dependent on the climatic conditions, the most favourable season for growth showing the highest efficiency. The fluctuations in the subsoil water table is another factor which is found to influence it to some extent also. A definite varietal variation is also observed, the utilisation of water by Pundia being much less than POJ 2878; but from the study of its root system as well as its behaviour during the stress period of summer months, it is considered that Pundia would require the maintenance of a higher level of soil moisture for its physiological activity than the other variety.

The water requirement of the crop is found not to be the same throughout the life cycle of the plant, it being the highest during the grand period and flowering stages and least during the maturity stage. Out of these the early grand period stage (mid-May to mid-June) is considered to be the most critical period in the life of the plant. The adjustment of waterings according to the periodic requirement would be therefore, an efficient system of the distribution of the total delta and the experimental evidence has shown that in 95" thus can be achieved by keeping a constant ten days irrigational turn varying at the same time quantity as per requirement. Shortening this interval during summer (eight days turn) has not resulted in any significant improvement, while delaying the irrigational turn beyond ten days (fortnightly irrigations) during summer, is found to check the growth of the crop to a very great extent, and even regular treatment later on does not accelerate the activity. On the other hand, leading the crop to the permanent wilting stage; once during its life cycle under either in April or May has not affected the yield. The period required to attain this condition varies between 21 to 54 days depending upon the variety and the physical condition of the soil. It has been found that, irrigation at the end of this period produces new fresh roots which give a fillip to the physiological activities of the crop, leading to its rapid growth. Experiments on the interrelationship of water and manure which have been started recently have shown that while in general there is a stimulation of the vegetative activities with increasing doses of nitrogen, the higher doses of water tends to diminish it by hastening the flowering and the maturity.

(5) *Other crops*.—Singh and his co-workers(2) have calculated from their pot culture studies the water requirement of tobacco, potato, oats, barley, linseed, pea and mustard as 30.1, 20.4, 8.1, 7.8, 6.4, 5.6 and 4.34 acre inches of water respectively for the whole of the life cycle. At Nadiad in the Bombay Presidency, a normal crop of tobacco is obtained on 7.5". A great deal of field experimental work has been done in Sind in order to fit the crops into the Kharif supply of irrigation. It has been found that *jowar*, *bajri* and *til* yield normally on a delta of 27", 21" and 21" respectively. The total for rape and gram ranges between 14 and 17 acre inches, and for *Jambho*, *Toria* and late sown mustard 14 acre inches. As regards the miscellaneous and garden crops, ground nuts, tobacco, soya beans, potatoes, onions have been found to give normal yields on 34", 35", 32" and 26" respectively. Investigations at the Dry Farming Research Scheme, Sholapur, on

investigations on this problem; and it is considered, that for its successful elucidation it would be essential to evolve a standard uniform method of field experimentation and record for each crop for adoption in different provinces as has been done for the trial of the sugarcane varieties

(c) *Suggestions for the future*.—(1) It is evident from the review that during recent years, investigations are in progress in different provinces on one or more of the important factors influencing the water requirement of crops. In planning future research, therefore, the first prerequisite is the co-ordination of all the available data on systematic basis and the layout of definite lines of investigation and record for adoption at various centres. This would be quite essential for the generalisation on the influence of the various factors which would eventually enable one to state the water requirement of the crop for different soil types, climatic conditions, etc.

(2) The following problems specific to the canal irrigation would require investigation :—

(a) As in the canal irrigation the critical factor is the amount of water available for the land, the minimum water requirement of the crops is required to be determined with a view to get the optimum outturn for a given supply of water

(b) The influence of the range of sowing and planting periods for various crops on the economical and efficient use of water

(c) Besides selection and breeding of improved varieties, introduction of new species for the better utilisation of water

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(1) *Leather*.—Pusa Memoirs—Chemical Series Vol I Nos 3 and 10, 1909, 1911.

(2) *Singh, Singh and Singh*.—Proc of the Ind Ac. Sci., 1935, I B 472.

(3) *Sen*.—Ind. Jour. of Agri Sci 1937, VII, 89

(4) *Subrahmanyam*.—Current Science, 1937, V No 12.

(5) *Bal and Misra*.—Agric and Live Stock in India, 1932 II, 404

(6) *Howard and Howard*.—Pusa Bull, 118, 1921.

(7) *Shaw and Kashi Ram*.—Agric. and Live Stock in India, 1934, IV, 465

(8) Questionnaire on conditions predisposing to harmful soil saturation which may ultimately result in waterlogging.

Publications of the Central Board of Irrigation.

(9) *Singh and Singh*.—Proc. Ind. Aca. Sci., 1936, IV B, 375

In addition the following reports have been consulted —

(1) Annual Reports of the Dept of Agri. of various provinces.

(2) Review of Agri Operations in India

(3) Quarterly Bulletins, Govt. of India, Central Irr Board.

(4) Reports of the Manjri Exptl. Farm

(5) Note on the Effluent Farm, Poona, 1918-19 to 1925-26.

(6) Annual Reports of the Sugarcane Research Scheme, Behar, U. P. and Bombay.

(7) Reports of the Bombay Dry Farming Research Scheme, Sholapur.

of the previous year. A definite quantity of water was allowed to flow (definite area and water was measured by Vnotch. Three duties, *viz.*, 25, 30 35 were tested, *i.e.*, one cusec of water was allowed for 25 acres and com with an equal quantity of water allowed for 30, and 35 acres in separate blocks

The following results were obtained —

(1) The transplanting of rice was completed in twelve days with duty 25, in seventeen days with a duty of 30 and twenty-seven days duty of 35. The rapidity with which transplanting could be comp is an important consideration in the rice cultivation on innundat canals since rice fields transplanted after rains set in, have poor g. and produce crop.

(2) The following quantities of water were utilised for raising of rice crop :

Duty.	Quantity of water consumed in acre inches		
	Soaking dose.	Maintenance dose.	Total.
25	8·2	40·6	48·8
30	8·7	47·5	56·2
35	9 4	36·0	45·4

The maintenance dose was highest during transplantation and went decreasing towards the latter stages of the crop. With 30 duty, daily maintenance does per acre was 0 52 inches for first 55 days, 0 inches for next 40 days and 0 24 inches for remaining 26 days.

(3) The yield of crop was as under .—

Duty.	Yield per acre Md.	Sr.
25	18	8
30	14	0
35	9	5

Conclusion.—In non-barrage areas on innundation canals, normal crops with fa good yields could be obtained with 30 duty and transplantation completed with an adequate period and before rains On the other hand it was not possible to g better yield with 25 duty which was found to provide water in excess of requirements so much so that the water course had to be kept closed for days The only advantage in 25 duty was the rapidity with which transplant of entire holding could be completed On the other hand the duty of 35 althou it provided sufficient water to raise a crop successfully, caused the period transplanting to be rather prolonged with consequent risk of damage to transplanted crop by rains.

It is proposed to undertake such large scale field experiments to determine correct duty of irrigation in the production of major crops in the non-l and barrage areas of Sind on zamindari lands and under zamindari condition the same lines as the duty experiments on the rice crop in the Fuleli Canal tr (non barrage area) carried out in 1935 and 1937

APPENDIX VIII, C.

Selection of varities for special conditions of gro[illegible]

(Note received from the Government of Bihar.)

Since the inception of Sugarcane Research Scheme in the Province [illegible] items of programme that has engaged special attention is the selection [illegible] for special conditions of growth. These special conditions are a normal [illegible] some of the localities. The studies thus conducted, year after year, [illegible] problems of fundamental importance to cane growers and these [illegible] briefly stated are :—

1. Drought *resistance.*
2. Waterlogging and flood resistance; and
3. Usar tolerance

Each *of the problems* has been tackled from all the possible [illegible] Physiological, Chemical, Biochemical, Agronomical, etc. The results [illegible] may briefly be summarised as under —

I. *Drought resistance.*—In connection with the problem of drought [illegible] *types of root system have been observed in sugarcane varieties* :—

(*a*) Semi mesophytic

[illegible]

as wind breaks or at places exposed to high winds. The illustrations of the class are Co. 326, Co. 285 and Co. 205.

From the above it readily follows that as varieties possess different types of water absorption and conduction system, they would naturally cause a variation in their relative efficiency of water requirements. With this in view water requirement studies have been extensively conducted at the Station under field and controlled conditions which reveal that relative efficiency of water requirement of varieties does not bear any relationship to their capacity to resist drought (Table I).

Table I

Water requirement of varieties and their relative efficiency.

Sub-plot reference.	Dry matter per acre Tons.	Total water loss per acre Tons.	Water requirement of varieties	Relative efficiency of water requirement.
Co. 331 . .	5·35	273 88	47·42	1·00
Co. 210 . .	2·44	281 6	115 1	0·41
Co. 326 . .	2·103	370 26	118·3	0·40
Co. 313 . .	3 334	438 02	130·07	0·36
Co. 213 .	3 71	527 78	142 0	0·33
Co. 285 . .	2·36	367 18	155 0	0·31
Co. 299 .	1·47	262 24	236 7	0·27
Co. 205 .	1 15	274 12	238 7	0·20
B. 6308 . .	0·39	132 44	344·7	0·13
Co. 281 . .	1 12	477 4	425 8	0·11

The results from both the sources have, however, indicated a high co-efficient of correlation ($r = 0.82 \pm 0.066$ – controlled sets) between the yielding power of varieties and relative efficiency of water requirements of varieties. Accordingly the above varieties can, then, be broadly classified as —

1. Most economical—Co. 331
2. Less economical—Co. 210, Co. 326, Co. 313 and Co. 213
3. Least economical—Co. 281, Co. 205, Co. 285, Co. 299 and B. 6308

Incidentally the controlled weighment set suggested a negative correlation ($r = -0.68 \pm 0.1787$) between the mean relative transpiration ratio of varieties and their mean absorption capacity. This is in accordance with what was mathematically arrived at by Huber (Maximov—Plant in relation to water—1928) that the process of transpiration was not only controlled by the transpiring organs of plant, but was also influenced by its absorption system. The rate of transpiration loss per unit leaf area also does not bear any relationship to the relative efficiency of water expenditure per unit of dry matter produced by various varieties since sugarcane varieties do not differ very widely in respect of the water content of leaves. Under extreme conditions of drought the depression in water content of leaf hardly exceeds 3-4 per cent. and the depression in the Xerophytic ones is in no case greater than the semi-mesophytic ones.

Several Physiologists notably Russian workers have shown that water content in the leaf promptly affects metabolic activity of the plant. Therefore, studies on the metabolic activities of some eight varieties during an advancing hot weather were carried out with a view to understand the connection between the rate of metabolism of plants and the drought resistant capacities of the varieties. The results are summarised in Table II given below —

Table II.

Showing results of Metabolic activity during an advancing hot weather.

Period of observation.	Varieties							
	Co. 214.	Co. 299.	Co. 313	Co. 210	Co. 213.	Co. 331.	Co. 336	Co. 326
2nd May to 10th May 1934 . . .	0·94 ccs	0·63 ccs	0·72 ccs	0·75 ccs	1·00 ccs	0·91 ccs	1·13 ccs	0·74 ccs
11th May to 20th May 1934 . .	0·93 ,,	0·73 ,,	0·80 ,,	0·74 ,,	0·76 ,,	0·44 ,,	0·11 ,,	0·52 ,,
23rd May to 2nd June 1934 . .	0·84 ,,	0·57 ,,	0·45 ,,	0·61 ,,	0·31 ,,	0·51 ,,	0·60 ,,	0·53 ,,
3rd June to 13th June 1934 . .	0·61 ,,	0·41 ,,	0·51 ,,	0·21 ,,	0·27 ,,	0·60 ,,	0·43 ,,	0·53 ,,

A following of the results indicates that the decrease in the rate of respiration, as season advanced and the conditions of drought became more intense, was more or less inversely proportional to the drooght resistant capacities of varieties. For instance Co 213 and Co 356 that are semi mesophytic showed greater decrease than Co. 331 or Co 326 that are Xerophytic in nature

Similar studies were carried out during senescent phase of the growth of cane varieties Respiratory activity of roots and leaves during that phase of varieties known for their drought resistance had lower rate of respiration of their roots than varieties of semi mesophytic nature (Table III)

TABLE III.

Metabolic activity of leaves and roots during senescent growth phase of plants.

Varieties.	Roots	Leaves.
Co. 205	0·059 ccs	0·348 ccs
Co. 285	0·107 ccs	0·252 ccs
Co. 326	0·120 ccs	0·222 ccs
Co. 210	0 121 ccs	0·37 ccs
Co. 213	0·287 ccs	0 198 ccs

Leaf respiration, however did not suggest any such relationship The significance of such results is self evident for unless Xerophytic varieties possess low metabolic activity they would be unable to force their roots deep down into the sub soil during a period of drought

II *Waterlogging and flood resistance*.—It has been shown above that vital activity of plant is linked up with the reaction that the varieties with different capacities to resist drought exhibit when adverse circumstances come to exist In the problem of waterlogging and flood resistance also an understanding of the behaviour of vital process is of supreme importance The above given results (Table III) are equally applicable here for "Root growth-oxygen relationship is an important consideration when varieties have to contend against deficient oxygen supply around their root system Moreover the rate of intake of water is regulated according to the energy generated by the process of respiration A variety with lower rate of respiration will naturally take up at a more well regulated rate than a variety possessing high rate of respiration and in consequence avoid excess intake Thus it is that Co 205 Co 285 and Co 326 that possess lower rate of respiration are able to withstand conditions of prolonged waterlogging and flood without any significant injury

Tolerance to Usar of Co varieties in descending order.

Highly tolerant.	Tolerant.	Highly susceptible
Co. 326	Co 210	Co. 290
Co. 275	Co. 391	Co. 300
Co. 285	Co. 331	Co. 340
Co. 318	Co. 371	Co. 213
	Co. 312	Co. 349
	Co. 336	Co. 343
	Co 313	Co. 373
		Co. 281
		Co. 299
		Co. 214
		Co. 370

The roots of sugarcane were found to grow normally within a range of pH 6·1 to 77, the values below neutrality telling more adversely than those above it within this range All values beyond this range were toxic to a varying degree In 'Usar' soils roots were found to be more branched at deeper layers and the laterals comparatively thicker Flaccidity at ends; profuse branching in the case of surface roots and reddening of roots tips with swelling behind them; slender and meagre development of laterals in deeper layers were some of the characteristics found in roots in acid cultures.

APPENDIX VIII, D.

Water requirements of crops and an appreciation of the present position, with suggestions for the future.

(R. S. L. JAI CHAND LUTHRA, I.A.S., *Professor of Botany, Punjab Agricultural College, Lyallpur.*)

No regular work on estimation of water requirements has been undertaken here. Some preliminary work on the determination of rate of transpiration in American cotton was conducted in 1935. 4-F type of American cotton (G. hirsutum) was taken for the study.

1. The following is the brief account of work done in this respect :—

The rate of transpiration was compared with evaporation and maximum temperature. A high correlation between transpiration and these factors was found.

With the increase of soil moisture, there is a definite increase in the total transpiration and in the leaf area. Transpiration rate is 30 per cent. of evaporation rate during September, when maximum leaf development is attained, and 31 per cent. during July, when evaporation is very high.

Nearly 2,076 tons of water are lost by transpiration from an acre of cotton crop during the period of growth. Total water applied to the crop is estimated at about 2,837 tons.

Nearly 1/3rd of total water transpired by a cotton plant is lost in the month of September.

Maximum transpiration occurs in the afternoon between 1 P.M. and 3 P.M.

2. Experiments on water requirements have been laid out at the Dry Farming Research Station, Rohtak under the Dry Farming Research Scheme of the Imperial Council of Agricultural Research. This investigation is being carried on on *Jowar* (*Andropogon sorghum*) and *Bajra* (*Pennisetum typhoideum*). Results so far obtained are as follows :—

In *Jowar*, water required for producing one gram of dry matter amounts to 254 c.c. in medium loam and 303 c.c. in heavy loam. In case of Bajra, the amounts are 303 c.c. and 320 c.c., respectively.

APPENDIX VIII, E.

Water requirements of crops—influence of date of sowing on yield of paddy crops in Bengal.

(D N. SEN GUPTA, *Executive Engineer, Bengal.*)

(i) The subject of the water requirement of crops *i.e.* the duty is very important in connection with preparation of irrigation projects The Agricultural Department of Bengal have studied this matter for the province But more inquiry about it is necessary to find out if the requirement is changed with a change in the date of sowing. In Bengal greatest demand on artificial irrigation is felt in the month of October, when supply in rivers is considerably reduced. Experiments in Sind show that early transplantation in June gives better yields It is a matter to be seen also, if early transplantation in June produces early maturity and the demand of water in October is reduced thereby

(ii) Usually only one crop is grown in the fields in Bengal But by a suitable adjustment of time, it may be possible to grow both a kharif and a rabi crop in a field If maturing of the kharif crop can be obtained early, a late variety of rabi can be grown on the field. Particularly in projects with storage reservoirs, there is likelihood of surplus water becoming available for rabi irrigation in years of good rainfall. Bengal soil remains fairly moist for sometime after the rains There are many rabi crops which do not require much more moisture With a little irrigation such crops could be brought to maturity. What these crops are, their water requirement and economic value should be studied In Bengal although the soil is fertile and rainfall copious crops particularly in Western, Central and Northern Bengal suffer occasionally for want of water due to the erratic distribution of rain. But it is difficult to make any irrigation project a good paying proposition if only one crop is grown On account of the permanent settlement no credit is obtained for any improvement in land due to irrigation If a good second crop could be grown, the position would be entirely different This matter is, therefore, of very great importance to Bengal

APPENDIX IX, A.

Notes on Subject VI (A review of work done on crop protection, an appreciation of the present position, with suggestions for the future.—

(a) with reference to protection from wild animals.

(b) with reference to inesects.

(c) with reference to fungi.

(d) with reference to parasitic flowering plants.

(e) with reference to effects of climate).

Crop protection from wild animals.

(W. J. JENKINS, M.A., B.Sc., I.A.S. *Director of Agriculture, Bombay Presidency*.)

A (1) *Introduction*.—It will be convenient to take as a starting point for this Note, the Report of the Committee appointed by the Government of Bombay in 1922 to consider and adopt measures for the protection of crops from wild animals and stray cattle. Prior to 1922, the Agricultural Department had done considerable work in the organization of "shikar" parties for the destruction of wild pig, nilgai etc., mainly in the sugar-cane growing areas. It became obvious however that action on a much greater scale was necessary, especially in the tracts adjoining forests, and the position was fully discussed at a meeting of the Bombay Provincial Board of Agriculture in 1921. At this meeting a recommendation was made for the establishment of a Committee which, as stated above, was formed in 1922.

(2) The main recommendations of this Crop Protection Committee are given hereunder :—

"(*a*) The direct damage annually done to crops by wild pigs and associated animals is estimated by the Committee at seventy lakhs of rupees in the Bombay Presidency and is increasing. The indirect damage done to the country due to loss of population, reduction of cultivation, increased unhealthiness of infested areas and the like cannot be given a money value, but if this were attempted it would mean an annual figure of several crores of rupees.

(*b*) As the eradication of the destructive wild animals and particularly of wild pigs is impracticable except in special cases, the methods adopted to deal with them must be essentially designed for the *protection* of crops from damage.

(*c*) Though extermination of wild pigs seems at present impossible, there is no reason to suppose that it will never be so if the habits of these animals are better known. It is recommended that a specially suitable officer should be deputed to study the wild pig in its own habitat for some years in order that the weak points at which it can be attacked may be ascertained. This will cost possibly Rs. 20,000 per annum and the study should last at least three years.

(*d*) The only really satisfactory method of protecting crops from wild animals and especially from wild pig is by fencing. This may take the form of a dry stone wall or of a specially woven iron fence, either of which can be made under suitable circumstances (and in the former case, if suitable stones are on the spot) for Rs. 1,400 to Rs. 1,800 per running mile.

(*e*) Such fencing, except with very valuable crops, must be the fencing of large area up to 1,000 acres, in order to reduce the cost per acre.

(*f*) Where cultivators are willing to co-operate to build such fences, *taggi* should be freely given for the purpose. The model bye-laws recently issued by the Registrar, Co-operative Societies, for such a co-operative effort are commended.

(g) Where the whole of the cultivators are not willing to co-operate in carrying out such fencing schemes, legislation should be undertaken to provide that if the owners of 75 per cent of the land are ready to bear their share of the cost and of maintenance, and if Government is satisfied of the utility of the project, the remainder of the land owners should be compelled to contribute.

(h) Government, as the owner of the forest areas from which the wild pigs came, should accept a definite liability towards the cost of the construction of such fences, when they are properly designed and conducted under supervision. It is suggested that such contribution should be one-fourth of the cost The remission of half the annual assessment for a number of years where such schemes are carried out is worthy of the attention of Government as an alternative

(i) Expert advice and assistance in the construction of such fences should be given free of charge by the agricultural officers of Government.

(j) Other methods are palliatives but are nevertheless important.

(k) Guns for crop protection should be allowed as freely as possible, particularly in tracts infested with wild animals It is recommended that such gun licenses should be issued to any owner of ten acres of land or more on application and free of any license fees

(l) Guns for crop protection should not only be held by individuals but also by villages as a whole the guns being in charge of the village panchayat (where such exists) or of the village officers Where such communal guns are held in a number of closely adjoining villages a man should be attached to the local police thana to inspect them and see that they are kept clean. The issue of communal licenses should not be held as a reason for reducing the number of individual licenses granted.

(m) Gun licenses for crop protection should be granted with the least possible delay, and by the prant officers of the district Inspection of guns held under license should be done in the village where they are held

(n) The policy of giving rewards for killing pigs now in force should be continued Success in crop protection with guns cannot, however, be measured by the number of pigs killed Everything should, however, be made as easy as possible for those who kill pigs to obtain rewards. The Committee are not sanguine that the extension of the system of giving rewards will make an appreciable contribution to the solution of the problem

(o) The orders regarding the clearance of a wide strip of land round cultivation in forests contained in Government Resolution No 414 A of April 7, 1922 (Revenue Department), seem satisfactory in this matter. The cultivators should be given assistance in the original clearing of such strips, and cultivation should be allowed on such strips for two years after the clearance commences

(p) The use of poisons has given promising results more especially in the protection of the more valuable crops, and not as means of protecting very extensive areas. The use of poisons (arsenic and strychnine) should be done systematically under the control of a responsible person or body of persons. If this is done there does not seem much likelihood that their use will be a serious danger to domestic animals No restriction should be made in the distribution of poisons to such responsible bodies of persons.

(q) The most efficient way of using poisons and preparing poison baits should be further investigated by the Agricultural Department

(r) While the Committee feel that poisoning on any ordinary scale will not deal with the pig trouble as a whole, they are not convinced that it might not do so (except near the Kanara forests) if Government would be prepared to plan it on a large scale as a regular campaign as has been done in the case of prairie dogs and some other animals in the United States. Whether such a campaign should not be undertaken is worthy of consideration, as it would probably pay well in the end.

(s) As regards hunting in the forests, the extension of the rules issued by the Collector of Kanara on March 10, 1923, to other areas than those specified in the order should be considered, and is recommended so far as it can be done consistent with the protection of forest property. All such rules should recognise that the agricultural interest is paramount, and that if any animal is found to do serious agricultural damage, this fact should dominate the situation Hunting of wild pigs organised or unorganised, should be encouraged everywhere

(t) In isolated tracts like the Deccan Canal areas the wild pig pest can be kept completely in check at a limited cost by the maintenance of hunting parties. It is recommended that two such organised hunting parties should be maintained for the Deccan Canal areas, at a cost of Rs 5,000 per annum for five years, and should be employed in these areas provided the cultivators will pay half the cost of their mianteuance, under the control of the Agricultural Department

(u) With regard to the trouble with deer and antelopes, the Committee cannot make very definite recommendations, but wish to draw attention to the increasing seriousness of the trouble and to the need for a special inquiry.

(v) Wild elephants are a serious pest in a limited area of Kanara and Belgaum Adequate rewards should be offered for their destruction and if this is done, they can be eradicated or driven away from cultivated areas"

(3) At the Meeting of the Board of Agriculture, held at Pusa in December 1925, the question of the protection of crops from damage by wild animals was included on the Agenda. The Sub-Committee, which dealt with this subject, took as a basis for its discussions, the recommendations of the Bombay Committee In its Report the Sub-Committee stated that damage to crops by wild animals appeared to be on the increase in a number of areas though by no means generally, and where such an increase was noted it was usually due to—

(1) the increase of the cultivation of intensive crops such as sugarcane and groundnut,

(2) the more strict reservation of forest and jungle areas,

(3) the prohibition of shooting of certain animals like bara simha, nilghai, sambhur, etc, which tends to the increase of other and more injurious animals

the "Gun Club" movement which will be mentioned later. Experimental work on the poisoning of wild animals was conducted but, largely owing to the danger to human beings and domestic live-stock, this method of attack has been abandoned

Fencing.—Since 1923, the organisation of the construction of fencing and of stone walls for the protection of crops from wild animals was taken up vigorously in the Southern Division of the Presidency Rao Bahadur S. S. Salimath, Deputy Director of Agriculture, Southern Division, has described this work in detail in an article published in the *Agricultural Journal of India*, Volume XXII, Part VI (November, 1927), *which deals with the utilization of stone walls for protection* purposes. It was found, however that the cost of the such stone walls amounted to about Rs 1,400 per running mile and that they required continuous attention and repairs for proper maintenance Accordingly more attention was given to the use of pig proof woven wire fencing (at a cost of about Rs 1,500 per running mile) and all further schemes were carried out with this material In all in the Southern Division of the Presidency 25 miles of stone walls and 60 miles of woven wire fencing have been erected under co-operative fencing schemes protecting an area of 1,51,000 acres of crops A similar woven wire fence was constructed at Bhadne in West Khandesh at a cost of Rs 6,000 but this measure did not find much favour with the cultivators probably on account of the high initial cost involved the comparatively short life of the fence and the constant repairs required It appears obvious that such a method of protection is only feasible and economical in the case of compact areas of irrigated crops and cannot be applied on an extensive scale in *jirayat* tracts

Gun Clubs.—With the appointment of a Special Shikar Officer under the Director of Agriculture, Bombay Presidency in 1924 considerable impetus was given to the organization of shikar parties against wild animals mainly pig This has given rise to the development of Gun Clubs in the affected tracts which movement has proved most popular with the cultivators and most efficacious in dealing with the trouble

A copy of the draft rules adopted for Gun Clubs in the Southern Division is attached (Annexure I) A brief account of the progress made by these organizations is given below

(*a*) *Southern Division.*—Later it was found very difficult to collect share capital required for fencing schemes and hence an attempt was made to start Gun-Clubs These Gun-Clubs were organized for hunting and shooting wild pigs, and they have been working successfully. The members of the Gun Clubs are the cultivators of the villages, who, however, are not required to pay any fees towards their membership, but only to give their personal labour to organise the hunting parties with guns, dogs and spears Such Gun Clubs have been organised mostly in the forest villages, along the border tract of the Kanara Dharwar and Belgaum Districts, where the pig trouble has been found to be very severe 16 group Gun-Clubs have been organised in 172 villages, and an area of 80,000 acres of crops is being protected. More than 1,500 wild pigs have been killed so far and a good many have been scared away. As a result of the work of these Gun-Clubs, it is being experienced that the wild pigs are gradually lessening in number in the area of the Gun Clubs and the damage caused to crops is also disappearing The Gun-Club organisations are found to benefit the cultivators indirectly as well, in that the night-watching of the crops is being dispensed with thus allowing them more rest and better health than before In addition the cultivators in 4 of the Gun Club villages have been able to plough about 1,500 acres of the fallow land lying uncultivated on account of pig trouble, and are at present bringing them under cultivation. Crops like groundnut and sweet potatoes which were subject to great damage before Gun Clubs, are now being cultivated with success

The Gun-Club activities are being well appreciated by the cultivators and the demand for such Gun-Clubs is fast increasing

(*b*) *North Central Division.*—In 1936-37, a group of villages in Bhusaval taluka, with, Salsingi as its centre, came forward to organise a gun club for systematic and regular hunt of pigs and nilgais A gun-club was formed with 10 villages as its constituents. Each village has its small Committee to raise fonds and to assist the hunting party whenever it comes to the village area. A central body, on which representation from each of the ten villages was obtained, was formed for the whole group In the first year of the operations some subscription from well-to-do cultivators only was collected and the District Village Improvement Committee, East

Special Shikar Officer with an adequate staff should be appointed by local Governments who will be entrusted with (*a*) the organization of "gun clubs" and (*b*) the supervision of their work in the field and forest. In certain tracts, adjoining forest areas, this work should receive primary consideration from Village Uplift Committees as the success of "gun club" activities results not only in better profits from crops but in an increase in the general standard of the health of the villagers who are thereby relieved from the work of crop-watching by night. Gun clubs must receive financial assistance from Government as, in most cases, their need is felt most strongly in semi-forest tracts where the cultivators are poor and very uneducated Such assistance should take the form of the supply of guns and cartridges rather than by cash donations It is possible that a cheap supply of ammunition might be made available to such organizations from Government arsenals.

Licenses for crop protection

Licenses for crop protection should be issued on a much larger scale than at present to responsible cultivators and the Forest Department Rules regarding shooting in reserved forests should be considerably relaxed in areas where reliable reports of crop damage from wild animals are received At present, such permission is only given up to the 31st December from the 15th of June This period should be extended to the end of February at the earliest as, during the months of January and February, cultivators have more leisure time for forming shikar parties and, in addition, the present limitation on hunting after the 31st December greatly limits the extension of the cultivation of valuable leguminous crops, *e g*, peas, lentils, gram, wal, etc, as a second crop after paddy in many areas

Co-operation of Police.

In the past, parties of military have been utilised for the hunting and destruction of wild animals in certain areas It seems to be worth consideration whether such work could not be incorporated in the annual training of armed police in the districts Here are a body of armed men, who are provided with guns and ammunition and who have to undergo annual training in their use I suggest that the destruction of wild animals in the jungle would furnish a better training, more in accordance with the conditions under which the armed police normally use their weapons, than by firing practice at targets on rifle ranges

Fencing.

With regard to fencing, this method of crop protection is of limited application only and should be applied to compact areas of valuable irrigated crops where the cultivators should be induced to undertake co-operative action for the protection of their crops by this method. There is much scope for research work into the cheapening of fencing materials and construction

Research work.

The recommendations of the previous Board of Agriculture Meetings regarding the appointment of a Special Officer for research work into the life-history and habits of wild animals, which cause damage to crops, should be given effect to as soon as possible Very little appears to be known regarding the habits, routine, etc, of wild pig, etc, and it is more than possible that this lack of information results in effective methods of control being neglected.

Experiments on trapping.

There is much scope for organised trapping—and subsequent destruction—of wild animals on the corral system in areas where these are numerous and cause much damage to crops In this connection, I give below an extract of a letter from a late Conservator of Forests, Bombay Presidency :—

> "A tank bed or similar places where pigs come to wallow at night is chosen and fenced around. The fence is usually constructed of coarse grass held together by strips of bamboos or stakes. This fence is not at all strong, but looks formidable, being some six feet high and thick enough to look solid. An opening not more than 6 feet wide is left at one place and the pigs soon get accustomed to entering and leaving by this. The opening has a stout fence on either side for a length of 20 feet or so. Parallel with the opening and separated from it by one of these stout fences is a trench some 15 to 20 feet long, 4 to 6 feet wide and 8 to 10 feet deep This trench has a stout fence on both sides and at both ends, and is concealed by a covering of thin branches and leaves One night when a number of pigs have entered the enclosure, the stout fences

Duties of the Sub-Committee.

It will be the duty of the sub-committee—

(1) to organise the programme of hunting as allotted to it by the Central Committee;

(2) to inform the Central Committee of the actual work done through the Police Patil or Secretary;

and

(3) to carry out all operations as set out by the Central Committee.

Control.

The Deputy Director of Agriculture of the Division will control all the operations of this club and will send copies of monthly reports received from the Central Committee to the Collector of the District and the Divisional Forest Officer of the Division and will consult them when necessary.

Guidance.

Mr. P. N. Bhide, M.Ag., Shikar Officer, Poona, will guide the operations of the club.

APPENDIX IX, B.

Protection of crops from wild animals and birds.

(KHAN BAHADUR M. MOHD. AFZAL HUSAIN, *Entomologist to Government, Punjab, Lyallpur.*)

Mammals.—Of the three main groups of animals which are injurious to field crops and fruit trees, that is mammals, birds and insects, the term wild animals may suitably be restricted to the mammals.

Review.—The subject of crop protection from wild animals was discussed in a meeting of the Board of Agriculture, held in Pusa in 1925, when the following resolution was passed :—

"The Board recommended that a specially suitable officer should be deputed to study the life history of wild pig in its own habits for some years in order that the weak points at which it may be attacked, may be found out."

The matter was again discussed in a meeting of the Board of Agriculture held in 1929, when the following resolution, with the amendment that 'the scope of enquiries should be limited to mammals only' was passed :—

"Resolved that the Board of Agriculture draw attention to resolution No. 4 of 1925, Board of Agriculture recommending that a specially suitable officer should be deputed to study the life history of the wild pig and recommend that the scope of the enquiry be extended to include all animals other than insects which do extensive damage to crops. The Board further recommended that a special officer with necessary staff be appointed to investigate the whole question of the protection of crops from the depredation of wild animals."

The list of mammals which were considered of sufficient importance to demand attention were the following :—

Elephants, *Wild pig*, *Deer of various kinds*, Neilgai, *Jackal*, *Porcupine*, *Monkey*, Hare and *Rats*. (Those in italics were considered of special importance).

The Provincial Board of Agriculture, Punjab, discussed the problem in the 3rd meeting of the Provincial Board of Agriculture held in 1925, and realising the importance of field rats passed the following resolution :—

"The Board are of opinion that the rat problem in the Punjab is very serious and deserves immediate attention and accept the proposals outlined by Mr. M. Afzal Husain's note and recommend that the Government be pleased to take necessary action."

On account of the scarcity of funds the matter did not receive any further attention and the question was further discussed in the 5th meeting of the Provincial Board of Agriculture held in 1929. After an elaborate examination of the situation, the Board agreed with the Director of Agriculture, Punjab, to approach the Government for sanction of temporary staff as outlined in the proposal made in 1925. Financial stringency, however, again prevented the matter being taken up.

Towards the close of 1934, the Government of the Punjab recognising the importance of rat control, from the view point of public health and agriculture, approved the proposal for a joint campaign to be carried out by the Department of Public Health and Agriculture against rats in 5 tehsils selected for the purpose. A total expenditure of Rs. 37,000 for a period of 12 months was agreed upon, the proposal, however, did not mature as the fund was not sanctioned.

Damage from wild animals continues to be as serious as ever.

Government of Bombay appointed a Shikar Officer some years ago and his work has been greatly appreciated. The details of work done are given in Appendix I.

In the Punjab, reports of serious damage by wild pigs, porcupines, rats, flying-foxes, monkeys, etc. have been common, but no concerted action has been possible. In fact, in certain localities, monkeys have been caught in large numbers and liberated in other localities, thus leading to severe loss from these mammals in their new homes. A scheme to organise a campaign against monkeys in the Kangra District is under contemplation.

Damage.—No precise information is available regarding the extent of damage caused by the mammal pests Enquiries were instituted in the Punjab in 1928-29 and according to the estimates of District Officers the loss was calculated at 5 to 52 per cent. of the crops. In Simla Tehsil, 1/6th of the total crop area was reported to be damaged through the combined depredation of hare, jackal, squirrel, monkey, etc. In Kot Khai tehsil the estimate was even higher.

The field rats alone are estimated to cause an annual loss of 5 crores of rupees, but even if this figure is reduced by 1/5th, the loss comes to one crore of rupees per annum and if all the other wild animals are responsible for 50 per cent. of this the damage done by rats and other mammal pests in the Punjab cannot be less than 1.5 crores of rupees.

For comparison, available figures of losses in some countries due to rats are given below.—

	Rs. Crores.
1. England	22·5
2. Denmark	9
3. France	1·2
4. Germany	15
5. America	60

In view of the above figures it cannot be denied that the estimate for damage in the Punjab has been put very low. The matter is of sufficient importance and deserves consideration, but without staff and funds it is impossible to undertake any effective measures of protection of crops from depredation of wild animals

Suggestion.—Action may be taken on the lines suggested by the Board of Agriculture, 1929.

Birds.

Review—Regarding birds the position is no better than in the case of mammals Very little work has been done in India regarding the status of birds in agriculture Only Lefroy and Mason undertook a preliminary investigation of the food of birds at Pusa. The results of their investigations were published in the Memoir of the Department of Agriculture in India (Vol. III, Ent Series, 1912)

In 1925 an assistant was detailed in the Punjab to study the food of birds The birds of Lyallpur have been studied, and the results are being published in the Journal of Bombay Natural History Society. Since 1928, a detailed study of the food, throughout the year, of the most important birds has been taken in hand and the control measures regarding the harmful species studied

The bird enemies of locust in Ambala District were studied in 1930, and the results published in the Indian Journal of Agricultural Science, Vol 1, Part V, Oct, 1931 and the bird enemies of Cotton Leaf Roller in Pirowal (Multan) in 1933 The results of this investigation are in the course of publication in the above journal

Present position—The work is being continued on the same lines on the feeding habits of the Large Indian Paroquet. The feeding habits of some more important omnivorous birds in other parts of the Punjab are being taken in hand This work at present is being continued by an assistant who is able to devote only a part of his time to the problems

A scheme for research in economic ornithology at a cost of Rs 41,075 spread over a period of 5 years was submitted in 1935 to the Imperial Council of Agricultural Research by M. Salim A. Ali through the Govt. of Bombay The Entomologist to Government, Punjab also submitted a scheme in the same year to the Imperial Council of Agricultural Research for sanctioning a whole time assistant Both the proposals have, unfortunately, not materialised.

The recent attempts to protect wild animals is likely to interfere in the balance of nature that had been established and the advantage and disadvantage of such protection in case of certain birds will receive proper attention.

Suggestion—The problem is of very great importance and the schemes submitted should be revised.

APPENDIX I.

Crop protection work in Bombay Presidency.

Year.	Wild animals destroyed.						
	Pig	Deer	Nilgai	Panther.	Rat.	Jackal.	Wild Cattle.
1928-29 .	141	..	..	4	..	.	..
1929-30 .	..	..	..	..	..	..	..
1930-31 .	142	175	30	..	..	..	..
1931-32 .	6 campaigns organised.	119	.		..	..	..
1932-33 .	180	..	..		.		..
1933-34 .	245	123	..	..	..	23	.
1934-35 .	441	51	.	..		12	15
1935-36 .	648	..	..	..	.	..	..

A 'Shikar Officer' is being maintained in the Presidency with limited staff since 1928. His policy consists of—

(1) Enquiry of damage by wild animals

(2) Organising Crop Protection Societies including—

(a) Gun Clubs,

(b) Shikar parties.

(3) Encouraging fencing of valuable crops on co operative lines

(4) Payment of rewards for the animals killed

(5) Public education

(6) Co ordination with other departments

APPENDIX IX, C.

Crop protection from insects.

(DR. HEM SINGH PRUTHI, M.Sc., Ph.D. (Cantab), F.N.I., *Imperial Entomologist, I. A. R. I., New Delhi.*)

I. The Desert Locust (Schistocerca gregaria).

Some evidence has been collected which indicates that there is always a thing population of this locust of the phase *solitaria* in the desert areas of Rajputana, Sind and Baluchistan (Mekran coast). Here and there in this region there are zones of th... population which are specially more numerous on the Mekran coast

The locust is very sensitive to changes in its environment, such as temperature, humidity, etc. Whenever there is sufficient amount of rainfall in the areas defined above, causing suitable wetting of the soil, the locusts start breeding and multiplying, sometimes giving rise to small swarms, the individuals still remaining of the solitary phase. The conditions under which bigger swarms arise and the individuals assume the phase *gregaria* are yet not fully known. Over-crowding of individuals in restricted areas seems to be one of the important factors

Regarding temperature, the locust can breed within a wide range (25°-40°C), the threshhold of development being 18°C.

II. Pests of Sugarcane.

(i) *Borers.*—The Stem borer *Diatraea stictiraspis* and top borer *Scirpophaga nivella* are the most serious in all parts of India, damaging on an average 10 per cent. of the crop.

Seasonal history and incidence.

Resistant varieties.—The same variety may be resistant to one borer and susceptible to another and may be resistant in one area but susceptible in another. The morphological or physiological characters which make particular varieties resistant are yet practically unknown.

Parasites.—Both borers have some important indigenous parasites which need proper investigation and development.

(ii) *Pyrilla.*—Two species (*P. perpusilla* and *P. pusana*) occur in India, not three, as hitherto believed. The pest is especially abundant after the rainy season when the humidity in the fields is high.

Control measures include bagging, collection of egg masses, removal of dry sheathing leaves, etc.

There are two important indigenous parasites, namely, *Tetrastichus pyrillae* and *Oencyrtus pyrillae*, which seem to be of potential value but which have not yet been investigated for control purposes.

III. Pests of Cotton

(i) *Spotted bollworms.*—Widely distributed all over India. Have a great variety of food plants.

Destruction of alternative food plants, complete removal and destruction of old cotton stems, stubbles, etc., are the usual control measures

Microbracon lefroyi seems to be a useful indigenous parasite the potentialities of which need a thorough investigation.

(ii) *Pink bollworm.*—Restricted in distribution. Incidence very much governed by climatic conditions.

Heating of seed to kill the hibernating larvae is a useful control measure

(iii) *The Cotton White fly.*—A serious pest in certain parts of the country only.

Spraying is an effective control measure

(iv) *The Cotton Jassid.*—A serious pest in several Provinces

Some resistant varieties.

(v) *The Cotton Stem Weevil* (*Pempheres affinis*).—Serious in South India only.

Some resistant varieties

Parasites.

APPENDIX IX, C.

Crop protection from insects.

(DR. HEM SINGH PRUTHI, M.Sc., Ph.D. (Cantab), F N I, *Imperial Entomologist, I. A. R. I., New Delhi.*)

I. The Desert Locust (Schistocerca gregaria).

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Some resistant varieties.

(v) The Cotton Stem Weevil (Pempheres affinis)—Serious in South India only.

Some resistant varieties

Parasites.

VI. Insect vectors of virus diseases.

Several crops suffer from serious virus diseases in various parts of the World, *e.g.*, potatoes, beat, tobacco, sugarcane, maize, Cruciferae, vines, peaches, roses, etc.

Most of the virus diseases are spread by insects. In India, tobacco, in Bihar and chillies in the Bombay and Madras Presidencies and sandal in South India are known to suffer badly from such diseases.

The common White-fly of cotton, *Bemesia gossypiperda*, has been found by experiment to transmit the disease of tobacco Thrips are suspected to do the same in case of chillies but conclusive evidence has yet not been obtained.

VII. Problems of all-India importance which need early attention.

(i) Effective measures to keep out foreign insects.

(a) Measures at the land frontiers as at sea ports.

(b) Necessity of keeping out pests of fruits and vegetables, against which there is no restriction at present.

(ii) Termites.

(iii) Survey of parasites,

(iv) Trial of Insecticides and fumigants under Indian conditions and preparation of insecticides from indigenous materials

(v) Taxonomy of insects of economic importance, especially of the following families :—

Noctuidae, Pyralidae, Coccidae, Aphidae, Aleurodidae, Acrididae, Coccinellidae, Cecidomyiadae, Syrphidae, Trypetidae (fruit flies), Techinidae, etc.

(vi) *Identification of Insects.*—It is desirable that some central place should have specimens of all insects found occurring on crops in all parts of the country. The Imperial Agricultural Research Institute, New Delhi, has the biggest collection of Indian insects named by well known authorities.

At present provincial workers sometimes send abroad insect specimens for naming which can be easily named at the Central Institute. Co-ordination in this matter between the Central and provincial institutes is desirable.

APPENDIX IX, D.

Crop protection from fungi.

DR B N. UPPAL, *Plant Pathologist to the Government of Bombay*

Ever since the dawn of man's history plant diseases have been the greatest hazards in the production of crop plants. In the United States it has been estimated that plant diseases take an annual toll of about a billion dollars, and the annual loss to crops in Great Britain is estimated at 15 to 20 million pounds sterling Such figures are better appreciated in the form used by Whetzel who said "The estimates of the plant disease survey of the U. S. Department of Agriculture indicate that approximately one bean in every dozen, one peach in every eight, one bushel of Irish potatoes in every twelve, and one bushel of wheat in every ten are destroyed annually by disease in these crops". Although no estimated figures are available for this country, it is certain that plant diseases are costing the people of India many crores of rupees Wheat rusts alone, for instance, have been estimated by Mehta to be responsible for an annual loss of about four crores Considering the magnitude of the financial loss, it is evident that crop protection from fungi is of paramount importance Although it is the primary concern of the plant pathologist to devise practical remedies against plant diseases since he exists for benefiting and promoting the agricultural industry of the country, yet he has sometimes unduly stressed the academic phase of research at the expense of the more practical aspects

Fungus diseases may be divided into two main groups—those of aerial parts of plants and root diseases. The diseases of the first group can be controlled by covering the exterior of the plant surface with a protective layer of a fungicide, either dust or spray, which is toxic to the germinating fungus spores which may alight on the plant surface. The other group of diseases is generally caused by soil borne fungi, which are not only difficult to control but the treatment of the soil with a fungicide is often not justified on account of the expense involved

It is proposed to review briefly the existing control methods with special reference to the work done in this country, including certain aspects of plant quarantine.

Fungi affecting aerial parts of plants

Sprays—The sprays in common use are elementary sulphur, lime-sulphur and copper sprays. The sulphur sprays are very effective against ectoparasites such as powdery mildews, whilst copper sprays are generally used to control endophytic parasites. Sulphur sprays have, in recent years, come into prominence in Europe and America due to the introduction of colloidal sulphur, the particles of which are finer than those of the finest dusting sulphur Since the fungicidal effect of sulphur depends on its fineness of division, colloidal sulphur sprays have been successfully employed for control of fungi against which coarser sulphurs have proved ineffective A good example of a colloidal sulphur spray is "Sulsol", a British proprietary product This fungicide has also been successfully employed against endophytic parasites In the Bombay-Deccan it effectively controls fig rust and is preferred to Bordeaux mixture which leaves a spray residue on the fruit that resists brushing Sulsol is a promising sulphur spray but no extensive trials seem to have been made with it in this country.

Among the copper sprays, Bordeaux mixture is still the standard fungicide, although a number of proprietary compounds of copper such as "Bouisol" are now available on the market. There is, however, a scope for further research on "stickers" substances which improve the adherence of the spray fungicides to the host surface In areas which receive heavy quantities rain during the monsoon, the problem of plant disease control becomes difficult since the fungicidal deposit is easily removed by rain and the plant is not protected for the requisite length of time. In the up-ghat areas of the Kanara District in the Bombay Presidency, control of "Koleroga" of betelnut caused by *Phytopthora areca* will be greatly facilitated by the discovery of a cheap and effective sticker.

Dusts—Sulphur is one of the best dust fungicides known A reference has already been made to colloidal sulphur sprays but sulphur in dust form is also now available in an extremely divided state Some of these sulphurs are composed of such fine particles as will pass a hypothetical sieve of two million holes per square inch. An example of this sulphur is "Lunevale" Microsul Dust, a British proprietary sulphur, which has a particle size of 4 to 5 microns.

Sulphur of the average fineness of 200 mesh is now extensively used for the treatment of plant diseases in the Bombay Presidency. Mango mildew and hoppers have been effectively controlled by dusting trees with sulphur which checks the mildew and acts as a deterrent against the hoppers. Sulphur dusting is also now commonly practised against powdery mildews of cumin, pea and of grape-vine, fig rust, "tambera" on potatoes caused by mites, etc. The success of the dust treatment is often dependent on the uniform application of the fungicide to the exposed plant surface. For this purpose a crank duster (Peerless Dnst Gun) is now made available in Bombay to meet the demand from growers; several consignments of these dusters have been imported by the Department of Agricultnre in Bombay, and the machines are sold to the growers at cost price

Soil-inhabiting Fungi.

Root diseases are more difficult to control in plantation crop than in an area under annual cropping. In the latter case the period between successive crops represents a vulnerable point in the economy of the fungus.

Rotation and cultural practices.—The fungus may persist in the soil in the form of resting spores or sclerotia. The established method to eliminate infection in such cases is crop rotation. The object of this practice is not the complete elimination of the parasite but the reduction of infection to the lowest level. However, since most of the soil borne parasites such as *Fusarium* wilts persist in the soil for long periods, rotation is not always a practical method of controlling plant root diseases.

Not much work has been done in this country on crop protection from soil-borne diseases through cultural practices including rotation and time of sowing. This matter, however, is not so simple as it appears since there are often considerable difficulties in modifying well-established agricultural practices.

Development of resistant varieties of crops—The development and nse of rssistant varieties of crops holds ont a great promise in the control of soil-borne diseases snch as *Fusarium* wilts (and other diseases such as cereal rusts), which cannot be controlled by any other means. A closer understanding between the pathologist and the plant breeder is needed to insure sound and substantial progrsss in evolving resistant varisties. For it mnst be realised that, although by his breeding method, the plant breedsr has given us lsrger and better crops, he has sometimes "discarded *en route* a number of hereditary genes which alone or in combination with others may be responsible for that vague but important character—constitution".

In the Bombay Presidency a considerable amount of work has been done on the breeding of resistant varieties of creps. A wilt-immnne strain of sann hemp has been isolated. In Kumpta cotton a wilt-immune strain has also been obtained, and great progress has been made in this respect in other cottons of the Presidency. The fact that wilt in cotton or in sann hemp is caused by a fungus, which is profoundly affected by environmental conditions in its capacity to produce wilt has led to the development of a method for testing the wilt reactions of cotton strains under uniform conditions of infection. This method has yielded every promising results, and it is described here in some detail.

Wilt resistance in cotton is mainly affected in its expression by two important factors: the degree of soil infestation by the pathogen and soil temperature. Assuming severe soil infestation, adverse soil temperature can induce temporary resistance in plants of the susceptible variety resembling the "inherited" resistance shown by the immune variety at all temperotnres If, on the other hand, susceptible types of cotton are grown in infected soil in a rango of optimum temperature, all plants must wilt. This, however, does not happen under field conditions "where variations in soil infestation by the parasite and in the seasonal climatic conditions preclude uniformly severe testing for resistanre".

The relation of environment to the development of Fusarium wilts in cotton or other crops is thus fundamental to the whole question of disease resistance, since the term "resistance" assumes different meanings when nsed with respect to a varying environment. It follows that field-selected strains must vary in their wilt reaction according to seasonal conditions and the degree of infestation of soil by the pathogen. For example, the highly wilt resistant strain of *Cajanus indicus* T 80, developed at Pusa, when tested in wilt sick soil at Arbhavi Farm, suffered 40 to 60 per cent mortality from wilt. It is obvious therefore that the great need in the study of wilt resistance is the development of a techniqne whereby comparable results may be obtained at different times.

the dry treatment with copper carbonate, organo-mercury dusts have been introduced. These dusts have largely eliminated the danger of seed injury, are easier to apply, and control certain diseases such as stripe of barley (*Helminthosporium gramineum*) that resisted control by the old fungicides A similar disease in rice (*Helminthosporium oryzae*) found in Sind, which has so far resisted control by ordinary fungicides, may prove amenable to treatment with organo mercury compounds used as dust or steep. Nevertheless, there does not seem to be a great scope for organo-mercury compounds in India due to their high cost. Most of these compounds are of German or American manufacture, and since a regular supply of these compounds cannot be assured in times of international stress, it has always been our policy in the Bombay Presidency to discourage their use and introduce into agricultural practice only simpler and more easily obtainable fungicides.' As a general policy, only British proprietary compounds are preferred provided they are not very costly

Soil treatment.—Control of disease by soil disinfection with fungicides or heat, applied, either as dry heat, steam or hot water, is commonly practised in commercial glasshouses. This method is generally not applicable on a field scale due to the expense of treating large areas However, in the control of wilt in betelvines caused by *Phytophthora parasitica*, Bordeaux mixture is now applied to the soil at the base of the vines. The cost of the treatment in Bassein near Bombay comes to about Rs 100 per acre but growers now universally practise the treatment as the betelvine crop is very remunerative.

Effective control of certain root infecting fungi can also be obtained by soil amendment The classical examples are the control of potato scab by the addition of inoculated sulphur to the soil and of club root of crucifers by liming This method has limitations in the control of parasitic fungi since these organisms often show a tolerance almost as wide as their host plants However, where it may be economically feasible to control plant diseases by soil amendment, the change of soil reaction may adversely affect the beneficial bacterial and fungus flora of the soil.

Attempts have also been made to control plant disease by the application of artificial fertilisers to the soil. L. E. Miles has reported effective control of cotton wilt and rust in south Mississippi in the United States by the use of a fertiliser containing an adequate amount of potash.

Eradication

Eradication is another method sometimes employed in the control of plant disease. The barberry eradication campaign instituted in the United States has been claimed as a success in mitigating the damage due to black rust of wheat. Although barberry eradication has not completely eliminated black rust from the mid-western wheat belt of the United States, it has served its purpose by reducing the chances for the development of new races which, it is now well known are produced by hybridisation on the barberry. Citrus canker, when introduced on nursery stock in Florida, proved a very destructive disease and at one time threatened with extinction the citrus industry of that state A campaign for the drastic eradication of diseased trees was undertaken by the state, and in the course of a few years the disease was stamped out and at present is not known in that area. Another example is the compulsory uprooting and destruction of banana plants suffering from Panama disease in Jamaica In this case rogueing has not fully succeeded in keeping the disease in check since the causal organism, *Fusarium cubense*, is widely disseminated by natural agencies such as flood waters

Quarantine.

One of the primary obligations of plant pathology is to prevent the promiscuous interchange of dangerous plant pathogens between different countries by the aid of plant quarantines, which may be defined as "legal restrictions on the movement of commodities for the purpose of preventing or delaying the establishment of plant pests and diseases in areas where they are not known to occur" This pre-supposes a knowledge of the parasites and their hosts and their inter relations This knowledge can be gained not only by the study of life histories of parasitic fungi but also by carrying out plant disease surveys Unfortunately, however, the value of these disease surveys is not fully realised. "It is pertinent to ask how plant pathologists can be expected to meet new situations, to interpret old ones and to prepare for future emergencies if they do not have opportunity to make adequate studies of diseases as they exist and factors influencing their distribution and development. Plant disease survey studies, ecologic studies, are among the most important in the whole realm of plant protection, and yet

we are often so myopic as not to appreciate their value and provide for their support?" How aptly this statement portrays the position in this country?

There are biologists and growers who are opposed to plant quarantines on the ground that they are ineffective and interfere with trade. Although plant quarantines cannot be made fully effective unless the phytopathological service of a country considers its duty to protect the resources not only of its own country but also those of other countries, yet who can deny that the devastation caused by many introduced parasites could not be prevented? It is also sometimes argued that, because a disease is of relatively little economic importance in its home there is no danger if it is transported on plant parts to other regions where it is not known to exist. This is a fallacy since introduced parasites are often more destructive in a new environment than in their original home due to a disturbance in the state of native natural balance or biological *equilibrium*. *For example, chestnut blight caused by Endotia parasitica*, a disease of little consequence in Japan, has, on introduction into America, threatened to exterminate the native chestnuts in the latter country.

Measures for the control of plant diseases are carried out for *personal* gain but rarely for patriotic reasons. However, apathy on the part of a few growers in practising control measures may sometimes endanger the resources of their neighbours or a community. The campaign for the control of 'koleroga" of betel nut in North Kanara provides a *typical example*. In past years many growers did not practise control measures to the detriment of those who carried out these measures. It has now been realised that forceful persuation to get all the growers to spray their trees is the only way to gain the desired end. Measures on the lines of those adopted for the eradication of spotted bollworm in Gujarat would have produced very beneficial results in a short time. For it must be realised that successive crop failures in such areas as North Kanara, where no other crop but betel nut is cultivated, are attendant with tragic consequences to growers and far-reaching sociologic and even political implications.

I cannot do better than close this brief note by quoting the following lines from E. C. *Stakman, an eminent plant pathologist*:—

"There price of a sound, comprehensive national life is in these times wide-spread and intelligent scientific research" This quotation from Angell is *applicable to plant protection* as well as to problems in general. Botanical science can promise man better varieties of crop plants and can show how better to protect them against disease and other hazards. But to accomplish this there must be provision for basic research, to discover facts and *formulate principles*, experimentation, to determine when, *where and how* they can be applied profitably, and education to incorporate them into practice and capitalise on their value. We need not only fuller knowledge, improved skills and better techniques, but also a deeper and more widely diffused sense of obligation to science and to society and a determination to discharge it equally faithfully and honestly to both.

"There must be much good research, but much of it must be good for something. Only when *there is broader realization of the ultimate* value of basic research, not only to clarify situations but especially to provide a reservoir of facts and principles for future emergencies will it be possible to proceed as intelligently and effectively as necessary in plant protection. If past experience teaches anything, it teaches that the most *fundamental research* often is the most practical in the end. Plant disease situations continually change, because crops and pathogens and conditions change. New problems continually arise. Only by elucidating principles and accumulating wisdom through research can we forsee possible future developments and prepare to meet them. Apathy and lack of comprehension, rather than antagonism, are the greatest obstacles to research and progress. Many people still have a childlike faith that science can perform miracles. A new disease or insect pest menaces an important crop. The formula is to provide money and demand a miracle. "Miracles of science" may be a good figure of speech, but most scientific miracles are the result of long and laborious *search* and research, repeated many times. We hear much about preparedness. Preparedness is essential in plant protection but we had better prepare for the future before it arrives instead of after it is present or past. And preparedness must be based on research".

APPENDIX IX, E.

Work done on the study of plant diseases and their control at the Punjab Agricultural College and Research Institute, Lyallpur.

(RAI SAHIB L. JAI CHAND LUTHRA, I.A.S., *Professor of Botany, Punjab Agricultural College, Lyallpur.*)

I. Introduction

Relation of incidence of diseases to climate.—In making a survey of fungal diseases of the Punjab, regard has to be paid to the local influence of climatic factors on the life and growth of fungal organisms. The Punjab presents peculiarities of climatic conditions that have a great bearing on the incidence of diseases. It may be divided into three regions for taking a stock of the magnitude of parasitic or non-parasitic fungal flora.

Firstly, the north-west portion which is enclosed by high and low hills where the climate is typical of the cold regions and of submontane tracts.

Secondly, the north-eastern hilly parts of the Sivalik and Himalayan range, covering the districts of Simla, Kangra, etc. In these areas, forest conditions prevail and humidity is high enabling all kinds of fungi to thrive. The submontane parts also provide a very congenial habit for them.

Thirdly, the plains of the central, eastern and southern regions which are hot and dry. In these places, temperature is high and humidity very low. 120°F has been recorded in shade in some years. Several serious diseases caused by highly parasitic fungi simply cannot exist under these trying conditions. For example, the most destructive parasites, *Phytophthora infestans*, cause of potato blight and *Tilletia tritici*, the Bunt fungus the greatest enemy of wheat grain, luckily have no place here. Comparatively, the hot parts of the Punjab plains are, therefore, fortunate in escaping from many injurious fungi that occur in abundance in moist, temperate and sub-tropical climates. But those parasites that are hardy and have made a footing here bring about terrific losses, for example, Gram blight (*Phyllosticta rabiei*) a serious disease of gram; Smut diseases of wheat, oat, barley, jowar, sugarcane, etc., late blight (*Alternaria Sp.*) of potatoes, Root rot of cotton, Canker and Withertip diseases of citrus fruits, etc.

II. Some Important Diseases of Individual Crops and Fruits

Investigations on Plant Diseases of farm crops in the Punjab have been pursued since 1910 with such periodical amplifications as became possible by the provision of facilities of staff and funds. The work carried out is described below.—

Cereals.—*Wheat.*—The area under wheat in the Punjab is about 9.5 million acres giving the total yield in grain of about three million tons and contributing nearly one third of the total produce of India. The diseases that cause serious damage to the wheat crop are—

(1) Loose Smut (*Ustilago tritici*).

(2) Flag Smut (*Urocystis tritici*).

(3) Bunt (*Tilletia tritici*), and (*Tilletia indica*).

(4) Earcockle Eelworm (*Tylenchus tritici*).

(5) Leaf Spot (*Septoria tritici*).

(1) *Loose Smut.*—The life history of the causal fungus *Ustilago tritici* has been known for long now. The experiments carried out in the Botanical Section relate to the study of measures of its control and the influence of climate on its incidence. This disease occurs commonly in the Punjab wherever wheat is grown. The extent of damage varies a great deal. In some places, it has been found to be 30 per cent, for example, in Karnal, Gurdaspur, etc. Considering the damage on a moderate scale of 2 per cent for the whole Province, the loss amounts to 50 lakhs of rupees every year.

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The Hot Water Treatment as developed in America has been applied for several years, but it was found very cumbersome and difficult of adoption on farms as well as by farmers on account of the great accuracy with which the required lethal temperature of water had to be maintained by the use of a thermometer to avoid injury to seed. Efforts have been made to modify this method to make it easier to carry out or to devise a much simpler treatment. As a result of eight years trials the following new method has been devised.

It consists in the application of solar heat to kill the causal fungus within the grain. Wheat harvested from a wheat field containing smutted plants is soaked in water for four hours and exposed to the sun in the hot months of May to July for four hours or so till it gets thoroughly dried. During this period, the fungus in the grain is killed by the lethal action of sun heat The method has proved fully effective for the elimination of the causal fungus from the grain Several years trials have shown that there is no adverse effect of this treatment either on the germination capacity of the seed or on yield of the crop raised from the treated seed This method is decidedly a great improvement over the old Hot Water Treatment method, because of its being cheap, simple and very effective.

Experiments have shown that humidity promotes the growth of the causal fungus The incidence of attack of Loose Smut is higher in comparatively moist places, i.e., Rawalpindi, Gurdaspur, etc., than in dry localities, ie., Multan, etc

Publications

(1) Some Experiments on the Control of Loose Smut, *Ustilago tritici* (pers.) Jens., of Wheat

By

Jai Chand Luthra, and Abdus Sattar,

The *Indian Journal of Agricultural Science*, Vol IV, Part I, February 1934,

(2) The Loose Smut Disease of Wheat (Vernacular "Kangiari") and some New Methods of its Control,

Other important diseases of Rice are Wilt caused by *Fusarium sp*, Paddy blast caused by *Piricularia oryzae*, Leaf Blight (*Helminthosporium sp*) Bunt (*Tilletia horrida*) A scheme for the investigation of these diseases was sent up to the Imperial Council of Agricultural Research, but it was not sanctioned on the ground that the work would be undertaken at the Delhi Research Institute or in any other Province where rice is more important than in the Punjab The necessity for the investigation was however, recognized.

Maize

There are two important diseases of *Maize*

(1) *Smut* and (2) *Brown Spot* (*Physoderma*) —These occur in the hills, but have yet to be investigated both with regard to life history and control.

Jowar (*Andropogon Sorghum*)

Red Leaf Spot (*Colletotrichum graminicolum*) —Some work has been done on this disease and it has been found that it is seed borne But secondary infection also occurs from diseased plants through the air Detailed life history and alternative hosts have to be studied.

Grain Smut (*Sphacelotheca sorghi*) —This disease can be controlled by the treatment of the seed with copper carbonate dust

Long Smut (*Tolyposporium filiferum*) —This disease is fairly common and serious in Multan and Dera Ghazi Khan Districts Its life history is not fully worked out.

Diseases of Gram (*Cicer arietinum*) —Gram is the most important crop of the *barani* tracts of the Province Next to wheat it has the largest area of about 4 million acres under it.

Gram Blight —This disease is widely spread in the North Punjab, i e, Attock, Jhelum, Mianwali and Rawalpindi Districts, and has caused serious damage to gram In 1936 37 and in several previous years almost the entire crop was wiped out in Campbellpur When climatic conditions are favourable and the source of infection is present, it breaks out in other districts also, i e, Lyallpur Sargodha, Gurdaspur, etc.

The causal fungus *Ascochyta rabiei Phyllosticta rabiei* has been determined Its life history has been worked out along with measures of control The disease is carried by seed and is also produced by infection from diseased plant debris of the previous season's affected crop left in the field It has been demonstrated fully that by sowing healthy seed in fields which have been freed of the remnants of the previous crop, the disease can be prevented It is also essential that there should be no source of secondary infection The disease is carried from infected field to heathly crop during rains and storms In a locality where the disease is prevalent concerted action is necessary for a thorough clean up operation and use of healthy seed all over the place, so that all chances of secondary infection are excluded

Resistant types —Besides these methods of control trials have been carried out of 185 varieties of gram obtained from various parts of India and foreign countries to find out strains resistant to the disease Three French types F 8 F 9 and F 10 have proved highly resistant to the disease These are being further tested and multiplied. They will be used as parents for hybridization with improved Punjab types

Publications

(1) Some Preliminary Studies on Gram Blight with reference to its Cause and Mode of Perennation

By

Jai Chand Luthra and Kishan Singh Bedi

The Indian Journal of Agricultural Science, Vol II, Part V, October, 1932

(2) Life History of Gram Blight (*Ascochyta rabiei* (Pass) Lab *Phyllosticta rabiei*) (Pass) Trot on Gram (*Cicer arietinum* L) and its Control in the Punjab

By

Jai Chand Luthra Abdus Sattar and Kishan Singh Bedi

Agriculture and Live Stock in India Vol V, Part V, September, 1935

Wilt (*Fusariums sp*) —The causal fungus of this disease has been determined It lives in the soil Further work on the mode of infection and control is necessary. This disease causes serious damage to gram in the Central Districts of the Punjab.

Diseases of Cotton

Root Rot.—Comparatively there are only a few diseases which affect cotton crop. Of these Root Rot disease causes most damage. Both American and Desi varieties occupy an area of about 2·8 million acres. Both these types are attacked by the disease and a loss of about 16 lakhs of rupees occurs every year as a result of death of cotton plants at an early age and also at the flowering time Investigation of the disease has been carried on here for the last 5 years under a Scheme of the Indian Central Cotton Committee A part of the expenditure of the Scheme is met by the Punjab Goverment. The disease has been found to be caused by two species of *Rhizoctonia*—(1) *R. bataticola* and (2) *R. solani* Definite results have been obtained with regard to the relation of soil moisture and sowing time with the incidence of the disease On the physiological behaviour of the fungus, it is established that it thrives in anærobic conditions The disease is carried on roots of the cotton plant left in the soil after the crop is over. Several leguminous crops grown in the affected field have been found to be susceptible to the disease. Cereals are not attacked by it. Chemical analyses have shown that diseased roots contain a higher percentage of Calcium and Iron The investigation of measures of control is in progress Late sowing of cottons has given indication of marked decline in mortality

The other diseases of cotton that require attention are Angular Leaf Spot, Anthracnose, Wilt and Virus Some of these in certain seasons become serious, for example, Angular Leaf Spot caused heavy defoliation in 1936 Wilt is responsible for a great deal of loss of plants in Ludhiana District.

Publications

(1) Studies on the Root Rot Disease of Cotton in the Punjab I. Symptoms, Incidence and Cause of the Disease,

By

R. Sahai Vasudeva

The *Indian Journal of Agricultural Science*, Vol V, Part IV, August, 1935

(2) Studies on the Root Rot Disease of Cotton in the Punjab, II, Some Studies in the Physiology of Causal Fungi.

By

R. Sahai Vasudeva.

The *Indian Journal of Agricultural Science*, Vol VI, Part IV, August, 1936.

(3) Studies on the Root Rot Disease of Cotton in the Punjab. III. The Effect of some Physical and Chemical Factors on Sclerotia formation,

By

R. Sahai Vasudeva.

The *Indian Journal of Agricultural Science*, Vol VII, Part II, April, 1937.

(4) Studies on the Root Rot Disease of Cotton in the Punjab. IV. Effect of certain Factors influencing Incidence of the Disease,

By

R. Sahai Vasudeva.

The *Indian Journal of Agricultural Science*, Vol. VII, Part IV, August, 1937.

(5) The Root Rot Disease of Cotton,

By

Jai Chand Luthra.

Seasonal Notes, Vol. XI, No 2, October, 1933.

Diseases of Sugarcane.—Diseases of sugarcane are being investigated in connection with the Sugarcane Research Scheme of the Imperial Council of Agricultural Research. One Agricultural Assistant has been provided and he is being guided in this work. Last 3 years' experience has, however, shown that an Investigator of greater experience and higher training than an Agricultural Assistant is required for research on these diseases some of which have presented intricate problems.

Smut (Ustilago sacchari).—This is a very common disease in the Province specially on Coimbatore varieties. Its modes of infection and dissemination have been studied. It is carried within the shoot and on buds of cane sets. It is capable of transmission by spores from smutted shoots to buds of unaffected cane in the standing crop through air. It has been controlled completely by roguing and disinfection of sets with copper sulphate and mercuric chloride.

Red rot (Colletotrichum falcatum).—This has been the cause of serious damage to thick canes in Ferozepore, Amritsar, Lahore, and Karnal Districts. For its control in the Ferozepore District, a variety of red Mauritious cane and two varieties of Barbados canes, i.e., B. S. F. 12 (17) and B. 6308 were introduced 15 years ago. They were from redrot free stock and were gradually taken up by the farmers to replace their local infected canes. The result is that the entire cane crop of the district has been replaced by these varieties and there is practically no redrot now.

Mosaic.—Experiments were carried out for 3 years for the study of the effect of mosaic on yield of cane and juice in type Co. 223. Results show that mosaic did not cause any reduction either in yield or in the percentage of juice.

Publication

Some Observations on the Mosaic Disease of Sugarcane in the Punjab,

By

Jai Chand Luthra and Abdus Sattar

Indian Journal of Agricultural Science, Vol. V, Part VI, December, 1935.

Oilseed crops

Groundnut.—This crop is a recent introduction and is rapidly extending in the Ludhiana District. Diseases observed in this crop are Tikka (*Cercospora personata*), and Root Rot caused by *Rhizoctonia sp.* and *Fusarium*. But no further work has been undertaken for want of staff.

Brassica.—*Rape* (Toria and Sarson).—*Alternaria sp.* sometimes breaks out actively and causes serious damage at the fruiting time. This is the only disease of any importance.

Potato.—In the Punjab, the potato crop occupies an important position in the hills. In the plains its cultivation is limited on account of its susceptibility to frost. It is, however, grown on a considerable scale in submontane parts, i.e., Sialkot, etc. The hill crop is liable to the attack of *Phytophthora infestans* (Late blight). In 1914, the writer observed it at Simla causing serious damage particularly near Kufri. Many fields were destroyed by the late blight. Since then, it has not been reported from any part of the Punjab hills.

In the plains, potato crop is attacked by Early Blight caused by *Alternaria solani*. The application of Bordeaux mixture is helpful in checking the progress of the disease. Further work for study of the course of the disease and mode of infection under local conditions is needed.

Another disease that has recently come to notice in the Kangra Valley is Wilt: the causal fungus is *Fusarium sp.* This is under investigation.

Diseases of potatoes in storage.—Potatoes are attacked by several diseases during storage. One of these is tuber rot brought about by *Fusarium sp.* Previous disinfection of tubers with mercuric chloride is useful but a study of this problem in detail is required.

Other crops.—Diseases of minor crops, such as, melons, pea, caused by Mildews sometimes become serious. Treatment with Bordeaux mixture has been tried with success.

APPENDIX IX, F.

Crop Protection from parasitic flowering plants—Phanerogamic parasites.

(L S S. KUMAR, *Economic Botanist to the Government of Bombay*)

In comparison with the total number of species of the flowering plants on earth the number of species of phanerogamic (flowering) parasites are negligibly few. Yet some of these are of much importance in view of the great damage they do to economic crops These parasitic flowering plants are broadly divided into two groups, viz, holo and hemi-parasites The holo parasites being devoid of chlorophyll and being incapable of manufacturing carbohydrate food stuffs are entirely dependent on their host plant for their nutrition The hemi-parasites are partly dependent on their host for nutrition particularly so in the initial stage. Later in life they manufacture their own carbohydrate food stuff with the development of green leaves and they become partly independent and depend on their host for nutritive materials other than carbohydrates

The parasitic flowering plants differ in their mode of attack. Some of them are root parasites as for example *Satalam album*, *Striga* and *Orobanche* *Viscum album* (Mistletoe), *Cuscuta* (Dodder), and *Loranthus* parasitise the aerial parts of plants *Rafflesia* is an extreme example of a type of holo parasite in which the vegetative part is reduced to that of mycelial-like structure which becomes ramified within the tissues of its host plant The only indication of the presence of this parasite is at the time when it flowers outside the host tissue

Satalam album is an exception among the parasites as it is of great economic importance for the essential oil it yields The others are all destructive types which do considerable damage to their hosts

Of the destructive flowering parasitic plants *Cuscuta*, *Loranthus*, *Orobanche* and *Striga* are found in India A great deal of damage is done to some of the cultivated crops by *Striga* and *Orobanche* while *Loranthus* causes much damage to fruit trees, in particular to mango A species of Dodder attacks lucerne in India Besides lucerne, Dodder has not been observed to attack any other cultivated crop in this country whereas in Europe it is found on clover It is observed that *Loranthus* is gradually spreading and heavily infesting road side mango trees and even plantations Perhaps some measure to combat the spread of this parasite will have to be adopted in those places where it has begun to increase in extent In the case of *Striga* and *Orobanche* the spread is already very extensive and the damage caused is so considerable that they demand serious attention to check their further spread The question of checking the attack by these two parasites will be dealt with separately

The parasitic flowering plants again differ in respect of the mode of germination of their seed In the case of *Cuscuta* and *Loranthus* the seeds germinate independently of the contact with their host and they establish connection by nutation of the organ which first develops on the germination of the seed close to a host The seed of *Orobanche* germinates when moisture is available and unless contact with its host root is made soon it fails to develop any further and will ultimately die The species of *Striga* differ among themselves in respect of seed germination *Striga lutea* has become so dependent on host that its seeds fail to germinate unless the stimulus from the host root becomes available This appears to be an extreme form of dependence Seed of *Striga euphrasioides* germinate readily in water but requires supply of nutrition from the host for any further development

Striga.—*Striga* has a wide host range both among cultivated and non-cultivated plants Sorghum sugarcane maize rice *nagli* (*Eleusine coracana*), *kodra* (*Paspalum scorbiculatum*) and a few other millets are amongst the cultivated plants attacked by *Striga* Among the uncultivated gramineae some of the grasses act as its hosts

The distribution of *Striga* is very wide throughout India and Burma and it is found to cause considerable damage to Sorghum as compared to the other crops it attacks In some places the attack is so severe that Sorghum crop is completely smothered by the parasite The severity and the extent of attack varies from season to season and it is not possible to say the exact causes which influence attack or the degree of its manifestation In some instance a heavily infested field fails to show the same severity of attack in a succeeding year while a field apparently free or mildly infested may show heavy attack in a later year

There are three distinct species of *Striga* which differ in respect of their season of attack and germination of seed. *Striga lutea, S. Densiflora, S. euphrasioides* are the three species found on Sorghum in India. A fourth species, *viz., Striga Orobanchioides*, exists but does not attack economic crops There is yet another species of *Striga* namely *S. sulphurea* which is similar to *S. euphrasioides* in all other respects except for the sulphur yellow colour of its flowers. A complete survey of the distribution of the different *Striga* species has not been made and it would be interesting to obtain information on this point if possible In the Bombay Presidency collections made in the past seems to indicate that *S lutea* and *S. densiflora* are found in Gujarat, Deccan and Karnatak. The distribution of *S euphrasioides* appears to be limited to the Deccan.

In some parts of the Deccan *Striga* appears on "kharif jowar" while in others it appears on "rabi jowar". Where the *Striga* on "kharif" and "rabi jowars" are distinct ecotypes or not has to be determined.

The question of checking *Striga* infestation is a difficult one since it involves overcoming a number of problems. The seed of *Striga* remains viable for a very long time. In some instances it has been found that fields not under jowar for 12 to 15 years were heavily infested by *Striga* after all those years when sown with *jowar*. So complete eradication may have to be prolonged to number of years before any check can be effected. The production of seeds is very heavy A single plant produces many thousands of seeds which are easily disseminated by wind. The seeds are capable of resisting adverse conditions over long periods These points explain the capacity of *Striga* seeds to be viable for so many years

The most difficult problem to check is fresh infestation from non-cultivated areas, where *Striga* grows on wild host plants Any amount of careful cultivation and the destruction of the weed from cultivated fields do not minimise fresh infestation. To control *Striga* on non cultivated plants is not feasible

In South Africa and Rhodesia a great deal of attention has been paid to the eradication of *Striga* for the past 15 years and yet the parasite has not been brought under complete control by cultural practices alone Saunders who did much work on *Striga* in South Africa is of the opinion that breeding of *Striga*-resistant Sorghums offers a solution to the problem Dr Saunders has informed that his work on *Striga* is confined to evolving *Striga* resistant Sorghums to the exclusion of others.

The work done at Poona gives hopes that it is possible to evolve Sorghum types resistant to *Striga*.

Orobanche.—Of the economic crops attacked by *Orobanche*, many belong to solanaceous and cruciferous families There are a large number of species of this parasite and only two are at present known to attack cultivated crops, *viz., O. indica* and *O. cernua*. Both these species have been reported on tobacco to which they do considerable damage. The problem of *Orobanche* is in some respects similar to that of *Striga* The seeds of the parasite germinate in water to some extent but require contact with the host for further development The seeds remain viable for over ten years in the soil and the parasite reappears when a suitable host becomes available A few preliminary experiments carried out indicate that evolving resistant types of tobacco to *Orobanche* is much slower work in comparison with the work of breeding *Striga* resistant Sorghums

In conclusion the phanerogamic parasites few as they are present a serious problem to the successful cultivation of crops which they attack The eradication of these parasites is as important as the control of diseases and pests which attack crops Up to the present attempts to control these parasites by weeding and other practices does not appear to have offered a solution and because of this it is now suggested that breeding resistant types should be taken up as an alternative means.

APPENDIX IX, G.

Parasitic flowering plants occurring in the Punjab.

(RAI SAHIB L. JAI CHAND LUTHRA, I.A.S., *Professor of Botany, Punjab Agricultural College, Lyallpur.*)

There are four flowering plants which grow as parasites on farm crops in the Punjab and bring about serious damage in some places.

(1) *Broomrape belonging to the genus Orobanche, family Scrophulariaceæ*.—There are two species of it—(*a*) *Orobanche nicotianæ*, and (*b*) *Orobanche cernua* which occur on the roots of tobacco. *Orobanche cernua* is also found on Sarson, cabbage, brinjal, etc. *Orobanche* on tobacco is confined to Attock District, particularly Campbellpur Tahsil, and is a serious pest. It is found on Sarson in Rawalpindi, Ferozepore, and Gurgaon Districts. No work on this parasite has been done here, but the results obtained from investigations carried out at the Imperial Agricultural Research Institute, Pusa, have been applied for its control. The effective method for getting rid of it is to pull it out as soon as it appears above ground. Under no circumstances should it be allowed to grow to the flowering stage. By persistent roguing it has been suppressed a great deal at Hazro.

Publication

Broom rape

By

Jai Chand Luthra

Seasonal Notes, Vol. I, No. 1, May, 1924

(2) *Striga*.—It is a root parasite of sugarcane, jowar, sudan grass, etc., in this province. There are three forms of it.

(*a*) *S. densiflora*, (*b*) *S. euphrasioides* and (*c*) *S. lutea*. The first occurs mostly on sugarcane and the last two on jowar. In several places, lands are so much infested with it that tangled masses of its rhizomes closely fill up the sub-soil. Sugarcane grown on such lands is very poor. Similarly with regard to jowar, some lands seem to be permanently infected with the seed of the parasite. Experiments are being conducted at the Mona Remount Depôt, where about 40—50 acres are affected with Striga and every year when jowar is grown, it appears in profusion. As this parasite also like Orobanche propagates from seed, the best measure of control is to remove it at an early stage before flowering.

Publication.

Striga as a Root parasite of Sugarcane

By

Jai Chand Luthra

Agricultural Journal of India, Vol. XVI, Part V, September 1921

(3) *Cuscuta minor (Dodder) family Convolvulaceæ*.—This occurs rarely as a pest of farm crops. The only instance recorded of it was on Lucerne in Sargodha, Sialkot and Montgomery. On investigation, it was found that the seed of Lucerne was obtained from Peshawar and it contained seed of dodder. The infected crop was cut and burnt and there has been no further report of its appearance.

Another form *Cuscuta reflexa* is common on hedges of duranta and dodonæa. It is a matter of common sight on Ber. (Jujubee) which is its favourite host. It can be controlled by picking out every bit of its yellow branches and burning them.

(4) *Loranthus longiflorus, family Loranthaceæ*.—This parasite is found on Oak in forests, on mangoes, Melia (Bukain) in submontane parts such as Gurdaspur. But it is not common.

The major weather abnormalities and destructive meteorological phenomena which adversely affect crops are enumerated below :—

1. Excessive rains, floods ⎫
2. Scanty rains, droughts ⎬ Rainfall
3. Untimely rains ⎭
4. Storms, cyclones, depressions
5. Thunderstorms, dust-storms and hail storms
6. Cold waves accompanied by frost
7. Heat waves.
8. Excessive or defective insolation
9. High winds

It will not be possible to discuss fully the various phenomena referred to above, but we shall state very briefly some of their main features indicating, wherever possible, how far the destructive effects and loss of property may be mitigated by direct remedial measures or indirectly by affording relief in other possible ways

3 *Floods and Droughts.*—In India much of the rainfall occurs during the South-west monsoon (June to September); the intensity and distribution of rainfall during this season determine to a large extent the success or failure of crops Years in which very large abnormalities (i.e., excessive rain or "floods" and scanty rain or "droughts") occur are equally bad for crops If the deviation of the actual rainfall in a year is roughly more than twice the mean deviation in a series of years, that year may be defined as a year of "floods" or "droughts" according as the departure is positive or negative Analysing the monsoon rainfall in the thirty subdivisions of India during the sixty one years 1875 to 1935 it is seen that the years 1877 1899, and 1918 stand out very prominently as years of general drought while the years 1878, 1892, and 1917 are the years in which "floods" or excessive rainfall occurred over a large part of the country In two instances at least (1877, 1878 and 1917, 1918) "droughts" and "floods" occurred in adjacent years, but there is usually no regularity in time in the distribution of "droughts" and "floods" Areas of droughts or floods are, however, associated into centres of droughts or floods in the years in which they do occur

Table 1 gives the normal rain, the lower limit of abnormal departure from the normal and the frequency of "droughts" and "floods" during sixty one years in the different sub divisions It is interesting to note that when we consider a sufficiently long series of years, the frequencies of droughts and floods tend to equalise; also, areas with a very low average rainfall e.g. Baluchistan Sind Rajputana, etc., are those where the total number of abnormalities is maximum in areas like Konkan Bengal, Burma, etc., where the monsoon rainfall is above 40", the frequency of abnormalities comes down very much

TABLE I

Name of Subdivision	Normal	Mean deviation	Lower limit of abnormal departure	Floods	Droughts	Total.
Assam .	64	5·2	10·4	4	3	7
Bengal .	56	5·4	10·8	2	3	5
Orissa . .	44	5·0	10·0	5	2	7

Other factors like diseases and pests which affect crops are also influenced by weather, but these are being discussed separately by other speakers

TABLE I—contd.

Name of Sub-division.	Normal.	Mean deviation.	Lower limit of abnormal departure.	Floods	Droughts.	Total.
Chhota Nagpur	43	4·8	10·0	1	2	3
Bihar	41	6 5	10·0	7	8	15
United Provinces, East	34	6 4	10·0	7	6	13
United Provinces, West	33	6 3	10·0	3	7	10
Punjab, East-North	18	4·9	6 0	10	7	17
Punjab, South-West	7	2·5	4·0	8	3	11
Kashmir	22	3·5	6·0	3	8	11
North-West Frontier Province.	9	2·4	4·0	10	5	15
Baluchistan	2	0·9	1·2	11	12	23
Sind	5	3·0	4·0	10	7	17
Rajputana, West	12	3·9	6·0	7	5	12
Rajputana, East	23	5·6	10·0	5	4	9
Gujrat	31	7 1	14·0	5	6	11
Central India, West	32	5 1	10 0	4	3	7
Central India, East	35	7·5	15·0	3	4	7
Berar	28	5·8	10 0	5	4	9
Central Provinces, West	41	5 8	10·0	6	6	12
Central Provinces, East	46	5 1	10·0	5	4	9
Konkan	102	14 5	28·0	2	5	7
Bombay, Deccan	24	3 8	7·0	4	4	8
Hyderabad, North	30	5 9	10 0	5	4	9
Hyderabad, South	23	4 9	9 0	7	5	12
Mysore	2[illegible]	4 [illegible]	8 0	3	1	4
Malabar	71	12 3	20 0	5	3	8
Madras, South-East	12	2 6	4 0	5	5	10
Madras, Deccan	15	3 7	7·0	4	4	8
Madras, North	25	3·6	7·0	4	1	5

Floods.—We may now refer to the incidence of *actual* floods which devastate large tracts of the country particularly in the areas drained by the large river systems of India. Such floods occur usually during spells of very heavy rainfall over the catchment areas of the river systems. The frequency of heavy rainfall over India is being discussed in a forthcoming paper by Doraiswamy and Mohammad Zafar. With reference to the heaviest rainfall in a day which has occurred during 1891 to 1920, they come to the following conclusions.—

(1) Falls exceeding 5" in twenty-four hours have occurred over the whole of India excluding north-east Baluchistan and parts of the north-west frontier.

(2) Falls have not exceeded 10" in twenty-four hours over most of the interior of the Peninsula and of Burma and in a few districts in the central parts of the country.

(3) Falls of 15" to 20" in twenty-four hours have occurred all along the west coast including Gujrat and Kathiawar, on the South Coromandal coast, on the north Burma coast, in South Assam, in Bengal and parts of Bihar and Orissa and along the foot of the Himalayas.

(4) A few isolated falls of 20" and over have occurred in the plains.

(5) The greatest fall of over 40" has occurred at Cherrapunji in the Khasia hills.

When heavy rainfall occurs consecutively on a number of days, and particularly over the catchment areas of the rivers, the magnitude of the ensuing floods may well be imagined. For such large scale phenomena there is no immediate and direct remedy. But a careful sifting of the facts of forestry in India has shown long ago (apart from possible influence of forests on rainfall) that we are paying now for the errors of the past, for the indiscriminate and wholesale destruction of forests. The forest department has appreciated the vital importance of fully developed forests over catchments for checking erosion and the rapid drainage into the rivulets which discharge into the major rivers and their tributaries. By retarding surface drainage, the onrush of the waters is stemmed and the peak of a flood is as it were delayed and smoothed over. Planned afforestation of the denuded areas is the only remedy and the activities of the State in this direction should receive every support.

Droughts.—The problems raised by droughts relate not only to the careful collection of rain water in a system of tanks, bunds, lakes, etc., but also to the conservation of the available water in such reservoirs and in the soil as far as possible.

Methods of preserving sub-soil water, by surface cultivation, mulching, etc., are in use over dry-farming tracts where droughts are the rule, but in such areas the soil has usually a high water holding capacity. In areas like the Indo-Gangetic alluvial plains rain water percolates into lower layers and water in canals, wells, etc., is the only possible source of moisture in droughty years. If these supplies also fail, there is no remedy. When one reviews this problem it becomes clear that attempts should be made to check evaporation from the soil as well as from the sources of water supply like lakes, canals, tanks, wells, etc. The rate of evaporation is proportional to wind velocity and the saturation deficit. Although we cannot alter the general air circulation over the country, it is possible to delay the air movements at the surface and thereby to decrease the loss by evaporation. We shall refer to this subject again later on.

4. *Cyclonic depressions and storms*.—Besides the setting in of the monsoon early in June, its extension into India during July and August, and finally its retreat southwards in September and October, weather in India is influenced by other major phenomena like cyclonic storms and depressions.

(1) *Eastern depressions*.—The fluctuations in the intensity of the monsoon itself is to a large extent associated with a series of depressions which mostly originate at the head of the Bay of Bengal and travel in a north-westerly direction across the country towards north-west India, causing heavy rainfall along their track. The frequency of such depressions is three or four per month.

(2) *Western depressions*.—During the period November to May, a series of western depressions enter India through Baluchistan and the North-West Frontier, and move eastwards through North India towards the north-east frontier. These depressions cause cloudy weather and light rains accompanied later by cold waves in winter. Their frequency is on the average two in November, four to five per month during December to April and about 2 in May.

TABLE I—contd.

Name of Sub-division.	Normal	Mean deviation	Lower limit of abnormal departure.	Floods.	Droughts.	Total.
Chhota Nagpur . .	43	4 8	10·0	1	2	3
Bihar . . .	41	6 5	10·0	7	8	15
United Provinces, East .	34	6 4	10·0	7	6	13
United Provinces, West	33	6 3	10·0	3	7	10
Punjab, East-North .	18	4 0	6 0	10	7	17
Punjab, South-West .	7	2 5	4 0	8	3	11
Kashmir . .	22	3·5	6·0	3	8	11
North-West Frontier Province.	9	2·4	4·0	10	5	15
Baluchistan . .	2	0·0	1·2	11	12	23
Sind	5	3·0	4·0	10	7	17
Rajputana, West . .	12	3·9	6·0	7	5	12
Rajputana, East . .	23	5·6	10·0	5	4	9
Gujrat	31	7 1	14·0	5	6	11
Central India, West .	32	5·1	10·0	4	3	7
Central India, East .	35	7·5	15·0	3	4	7
Berar	28	5·8	10·0	5	4	9
Central Provinces, West .	41	5 8	10·0	6	6	12
Central Provinces, East .	46	5 1	10 0	5	4	9
Konkan . .	102	14 5	28·0	2	5	7
Bombay, Deccan .	24	3 8	7·0	4	4	8
Hyderabad, North . .	30	5 9	10 0	5	4	9
Hyderabad, South .	23	4 0	9 0	7	5	12
Mysore . .	22	4 2	8 0	3	1	4
Malabar . . .	71	12 3	20 0	5	3	8
Madras, South-East . .	12	2 6	4·0	5	5	10
Madras, Deccan .	15	3·7	7·0	4	4	8
Madras, North .	25	3 6	7·0	4	1	5

The experience in America is that the losses due to the space taken up by the wind breaks, and due to the water removed from the fields by the root-systems of the trees and shrubs, are more than made up by the increased yields in the protected area and by the value of timber.

Before concluding this section it is interesting to note that a nation-wide awakening in regard to planting trees according to a well considered plan not only in our denuded forests, but also over our cultivated areas is urgently called for.

Conclusion.—Owing to the very wide scope of the subject of crop protection against adverse weather in a sub-continent like India with its varied climates, and crops, it has not been possible to do more than to touch in a very sketchy manner the various problems involved. While the methods of protection are simple and feasible in some cases, in others the isolated farmer is helpless without the aid of the State. It is hoped that the discussion to follow would supplement this brief note and indicate future lines of work.

References

(1) Walford—"Famines of the World" (Edward Stanford and Co.), p. 89.

(2) Ramdas, L. A.—*Current Science*, Vol. 3, p. 325, 1935.

7. *Heat waves*.—Just as cold waves are injurious to crops in winter, heat waves in summer are also prejudicial to their well-being*. The frequency of days with abnormally high maximum air temperatures, *e.g.*, 100°F, 105°F, 110°F, etc., has been computed for a net-work of stations in India. From charts showing these frequencies it is clear that the centre of high frequency of maximum temperature of 100°F and over lies in the Deccan and the central parts of India during March, April and May. The frequency increases from 20 in March to 30 in May over the Deccan, but once the monsoon sets in the centre of high frequency shifts towards North-West India. In July and August, Madras South-east is another centre of high frequency. The frequencies of 105°F and over show very similar tendencies.

8. *Excessive or Defective insolation; abnormally high or low soil temperatures.*—Insolation is a function of the inclination of the solar rays, the length of the day, and the transparency of the atmosphere. During clear days in summer, soil temperatures in countries like India reach very high values, particularly on days when air movement is weak. Experiments made at Poona show that on such days a thin cover of a white substance like chalk powder depresses the soil temperature at noon by as much as 18° to 20°C at the surface and by decreasing amounts lower down. A black cover is useful for absorbing the insolation fully and heating up the soil layers as much as possible during days with weak insolation. The effect of wetting the surface is to depress the soil surface temperature by about 15°C, but the cooling effect is due to heat loss by evaporation and would last only as long as there is moisture in the soil to evaporate.

The fundamental importance of clear sunshine to photo-synthesis in plants is well-known. During cloudy weather this activity is decreased, thus retarding growth; also conditions become favourable for certain diseases and pests. Cloudiness is also injurious to crops during certain critical epochs like flowering.

9. *High winds*.—The effects of high winds are many. The mechanical effect and possible damage to standing crops are obvious. If the air is cold, the effect of the high winds is to cool objects very rapidly and the result of such cooling of plants is disastrous if frost sets in. On the other hand, if the air is hot, the saturation deficit would be high and the rate of evaporation from water reservoirs, from plants and trees, will increase enormously. On such occasions, plants are known to wilt and die owing to the rapid desiccation.† In all these cases, it is obvious that the clear sweep of the winds across the country should be checked. Wind breaks are the only remedy. Wind breaks should consist of a line of trees planted as far as possible at right angles to the most frequent wind direction. When the trees grow up there will be gaps between the tree-trunks. These should be blocked by growing another line of trees or shrubs. The United States of America has considerable experience on this subject. "An ideal wind break for checking wind currents would have the contour of an earth dam. In the central rows would be planted the tallest trees, such as cottonwood on either side, rows of shorter trees such as ash and locust; and outside of these, low bushes or cedars. Such a wind break would not be easily penetrated, and its inclined surface would direct the air currents upward and relieve the horizontal wind pressure". (Farmers' bulletin, No 1405). In India we have to lay down similar specifications for an ideal wind break. The numerous effects of a wind break may be stated as follows:—

1. Checking air movement and thus affording protection to the fields and to orchards.
2. Checking of the movements of the top soil and consequent prevention of dust storms in areas where the soil is sandy or very fine.
3. Reducing evaporation; this happens in two ways, *viz.*, by reducing wind velocity and by decreasing saturation deficiency (due to water transpired by the trees).
4. They give shade to the farm.
5. Older trees would serve as timber and can be replaced by younger plants.

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* Lehenbauer (Smith, "Agricultural Meteorology", page 71) has shown that the growth rate index is only 1 at 4.5°C, and 45.00°C whereas it is as high as 110 at a temperature of 32°C; on the high temperature side the index decreases to 55 at 38°C (100°F) and to 30 at 40°C (105°F).

†The shrivelling effect of an untimely heat wave on grains at the milk stage is well known.

high temperatures—the spores do not lose their viability even at 29°F., the thermal death point of the spores being 55°C.

Symptoms.—The 'rati' disease first appears in the middle of August and reaches its maximum intensity by the end of September when the temperature goes down and there is heavier dew fall.

Control Measures.—Paddy seed treated for ten minutes in hot water at 54°C. gives complete control against primary attack at the seedling stage. But the process is tedious and likely to fail if sufficient care is not taken to maintain correct temperature and time. Chemical treatment by mercuric compounds although very simple to handle, gives full control over primary infections at seedling stage but provides no protection against secondary attack late in the season. Hot water and chemical methods of treating paddy seed having failed, breeding of resistent varieties was taken in hand. This work was carried out by the Rice Mycologist (Dr. Ramchandani) in co-operation with the Botanist (R. S. K. I. Thadani). Several improved strains of rice evolved by the Botanist formed the foundation from which selection of resistent progeny was to be made. The main rices of North Sind may be divided into two classes (1) early maturing—high yielding and medium quality rice, *e.g.*, Kangni—27 Hybrids between Kangni of Sind and Kolumba of Bombay; (2) Longer period of maturity—less yield and fine quality rices known as 'Sugdasi' or scented rices, *e.g.*, Jajai, Prong, Bengalo, etc. The detailed results of the work on breeding of resistent strains have shown that the hybrid strain of Kangni (Sind) × Kolumba (Bombay) rice called the 'Silver Jubilee' rice has maintained its high resistence to 'rati' disease and at the same time is high yielding. It has been further found that in almost all the principal varieties of rice under study it has been possible to get strains by selection which are far more resistent to 'rati' attack than the ordinary unselected seed of those varieties grown in the district.

The other fungoid diseases found in Sind are the boll-rot of cotton, rust of wheat and the root-rot found on many crops, *e.g.*, cotton, tur castor, soya-beans, groundnut, etc.

(*d*) *With reference to protection from parasitic flowering plants :*

So far no work has been done on the parasitic flowering plants damaging crops. The most noticeable pests in Sind are the Striga on jowar, Orobanchia on tobacco and Dodder on babul trees. In case of Striga on jowar, the only remedy found useful is not to grow jowar on the same land for a couple of years

(*e*) *With reference to protection from effects of climate :*

Crops in Sind are liable to seasonal variations and effects of climate. It has been found that if wheat is sown earlier than mid November in middle and North Sind, it is liable to attack by frost and if sown late, *i.e.*, after first week of December, to 'rati' disease. Long cloudy weather during the cotton growing season and rainfall bring about attack of Jassids and bell worm in cotton Westerly winds bring about sterility in rice Oilseeds are most liable to frost and insect pests under certain conditions of the weather Meteorological observations are recorded at Sakrand to correlate weather conditions with crop growing. More attention should be paid to agricultural meteorology.

So far the only steps taken to combat the weather conditions are finding out the optimum time of sowing of crops to escape the abnormal condition, *e.g.*, frost, irrigation of crops when frost is expected, combined with smoke screens, and greater study of the effects of climate on crops.

(8) The damage done by the injurious rats mainly affects rice and is of three different types, namely, the cutting of the seedlings, the sucking of the earheads in the milk stage, and the removal of the earheads when fully developed. The last type of loss is by far the most serious, and in plague years, may mean the loss of a large proportion of the crop. In ordinary years it comes to one or two annas in a rupee.

(9) Of all the poisons tried strychnine was found to be the best and quickest in action, its dose being 0 25 to 0 5 grain Barium carbonate and white arsenic are not so effective, their doses being 3.0 to 4 0 grains and 0 5 to 1.0 grain respectively. Plaster of Paris and "Farmer's Vermin Destroyer" (a proprietary phosphorus preparation), were found to be unsatisfactory even with high doses.

(10) The addition of *gur* (raw sugar), oils, etc , does not in any way improve the value of the bait, but on the other hand reduces it.

(11) Cooked flours and crushed wheat when mixed with poison form very good baits. About 5 to 8 grammes of the prepared stuff may be used for each burrow. The baits can be kept in the evening inside the burrows which are mostly found open. The results of the poison baits are not very satisfactory as only about 50 per cent. of the rats eat the poison and are killed.

(12) Fumigation with carbon bisulphide by means of the Suddeth Fumigator is the surest method of destroying the injurious rats. With one pound of carbon bisulphide it is possible to treat about 40 burrows Sulphur fumes and tobacco smoke generated by means of the White Ant Exterminator though found to be successful could not be produced so easily.

(13) Hand digging and destruction of rats if systematically practised will considerably reduce the number of rats though the work will be haphazard. But there is limited scope of this on account of the difficulty of getting skilled labour.

(14) The best time of the operation of fumigating is from the middle of August to the end of October. During this period most of the rats are attracted to the rice fields and their burrows are short

(*b*) *With reference to protection from insects* :

Preliminary investigation on the 'ruro' or 'mahlo' pest of rice in Lower Sind has been carried out. This disease is said to be caused by an insect belonging to the Jassidae family. The damage is caused by the extraction of sap from the leaves and the excretion of honey dew upon which sooty mould fungus (capnodium sp) grows. This disease spreads quickly and spraying in the early stages has been found to be useful. Of the spraying materials tried, Mahriol, a product of Burmah Shell has been found to give better results than Fish Oil Rosin Soap and tobacco decoction This disease if uncontrolled is likely to cause very great damage to the rice crop in Lower Sind It has been found that if there is a shower of rain when the attack breaks out, the insect disappears. The 'mahlo' disease of mangoes and of cotton are also caused by Jassids and require investigations The other important insect pests found doing damage in Sind are the white ant, spotted and pink boll-worms, the stem borers of jowar and sugarcane. Information on such insect pests found commonly in many provinces of India should be put together and compiled in the form of a bulletin by the Imperial Council of Agricultural Research, so that the Provincial Entomologists may be free to devote their time to local pests.

(*c*) *With reference to protection from fungi* :

The only research work carried on the fungoid diseases in Sind is the 'rati' or 'brown spot' disease in Sind under the auspices of Sir David Sassoon Trust Fund, by the Rice Myrologist (Dr. J. C Ramchandani).

Identification.—Dr. Ramchandani has found that this disease is caused by a fungus known as 'Helmintbosporium oryzoe Bredda de Hann.' The disease is carried both internally and externally by paddy seed and old infected straw The fungus also lives in the soil for a number of years. Comparative study of both Japanese and local strain of Helminthosporium oryzoe shows that both are practically identical in shape, size and colour.

Cultural experiments show that the fungus can grow on fruits, vegetables, cereals and sugars. The studies on Hydrogen Ion concentration show that the fungus can bear a very wide range of PH value. The fungus can stand very low and very

APPENDIX IX, L.

The desirablity of introducing legislation to control fruit nursery plant production.

(SARDAR SAHIB SARDAR LAL SINGH, *Fruit Specialist, Punjab.*)

It is no exaggeration to say that the greatest factor in the success of fruit industry is the supply of reliable nursery plants. Mistakes committed in the selection of plants cannot be rectified except at a great cost and that too after many years. It is very difficult and almost impossible for a purchaser to ascertain definitely the variety of fruit plants that he is purchasing and it is after many years of hard labour and immense expense that he discovers the genuineness or otherwise of his stock. It is the greatest risk that a fruit grower has to run. A mistake in this may mean a disaster to a fruit grower. The Royal Commission on Agriculture had rightly emphasized the importance of this aspect of the Fruit Industry. This question becomes all the more serious when we realise how reckless and unreliable most of the nurserymen are in this country and it seems almost a crime that they should be permitted to ply their trade of dishonesty There are numerous instances where people have paid Rs. 4 to Rs. 5 per plant which were alleged to be of bloodred variety of malta orange but which later on turned out to be most ordinary malta orange plants. Recently, a certain nurseryman was able to sell to scores of fruit growers in the Punjab, thousands of plants at a cost of Rs 5 to Rs 7-8-0 per plant which were alleged to be grape fruits of best quality but which on bearing turned out to be ordinary pomeloes or shaddocks worth a few annas each There are nurseries which are most seriously infested with all sorts of insect pests and diseases, and are serving as breeding centres for disease germs Other countries have been forced to enact legislation to control the production and supply of nursery plants—true to name and free from disease—but there is at present no law in India which would effectively prevent a nurseryman from committing such frauds Unless this is done, we may not be able to develop the fruit industry on sound lines in this country

In the Punjab we had tried a voluntary system of bringing on our list such nurseries which agreed to abide by our conditions but this method proved a failure. The other method is for the State, to produce the plants on a large scale for supply to people at reasonable price as is being done in other countries like Egypt, Palestine, etc , but this procedure is open to the objection that we are killing private enterprise It seems, therefore, necessary that we must adopt the same procedure that other countries have been forced to adopt, *viz.*, to enact legislation which would make it compulsory for every nurseryman to have his nursery registerde, to produce plants of only standard varieties, true to name and to keep his nursery free from insect pests and disease This legislation may appear to be drastic but unreliable nurserymen cut at the very root of the fruit industry which must be protected against the fraud of irresponsible people. After all the interests of a few nurserymen each producing a few thousand rupees worth of plants, are nothing as compared with the huge investment that fruit growers have to make and the consequent losses that they have to incur as a result of the dishonesty of these people. Irresponsible nurserymen, in order to make a profit of a few hundred rupees, make the fruit growers suffer a loss of tens of thousands, if not lacs of rupees. Details of legislation need not be discussed here.

APPENDIX IX, K.

Legislation to prevent importations of new varieties of sugar-cane by non-official bodies in provinces.

(Note received from the Government of Bihar).

I. The rapid development of the sugar industry as a result of protection has afforded an incentive to increased acreage under cane by the growers and the growing desire on the part of the miller and mill estates to import canes that have proved their usefulness in other provinces in the hope of getting better sugar and cane yields. Instances are not lacking where such importations have been made without reference to the local Department of Agriculture. Cases have occurred where canes that have not been approved of in a particular tract as a result of detailed trials by the Department have even been indented for. The latter cases have been particularly evident after the levy of internal excise on sugar and the fixation of minimum price both of which are alleged to have dwindled what margin of profit there was in the manufacture of sugar.

II. But in search of profits the miller has completely lost sight of the one fundamental law of Agrobiology namely, 'environment' Every agrotype has a certain range of adaptation in which it would do its best and that 'local suitability' is predominant phase of selection. Soil Type and its surrounding environment varies from place to place and what variety would suit a particular set of conditions remains definitely more a matter of trial under that set of conditions. Co. 281 is a case in view. This variety while not generally suiting this country has made its name in Florida and elsewhere. So that unrecognised importations of the nature discussed in I above can hardly lead to anything but chaos—and they have already led to disappointment in number of cases—as the Provinces may well be flooded in time with several varieties of cane of the characteristics of which the members of the Department be in complete ignorance. What is more menacing is danger of new pests and diseases accompanying such importations. This would certainly be negation of co-operative research.

III. It is therefore urged that such unchecked importations be put a stop to and the Agricultural Department given the fullest co-operation in their work to choose what is best for the tract and for the industry.

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APPENDIX IX, M.

The registration of and check on private nurserymen in British India and the issue of health certificates for export of live plant material.

(Note by the Director of Agriculture, Kashmir.)

It has been observed, for the last few years that a number of private individuals have started raising fruit nursery plants including ornamental plants for commercial purposes throughout India. All these petty nurserymen are advertising their stock even in publications issued by the Department of Agriculture None of these nurserymen despatched plants accompanied with Health Certificates, and to the best knowledge of the undersigned, none of the live plant material which is exported is fumigated or given any other treatment against plant diseases or insect pests, which any particular species of plant is apt to carry along with it.

Since last year, His Highness' Government, Jummu and Kashmir, have under the Crop and Plant Protection Regulation (Act No. 1 of 1990), placed a ban on the import and export of live plant material unless it is accompanied by a Health Certificate or checked by the Director of Agriculture. The section of the Act under which this action has been taken, reads as under :—

"Under section 4 of the same (The Plant and Crop Regulation, Act No. 1 of 1990) the Revenue Minister hereby notifies for the information of all concerned—

(iii) that the removal of any plant, tree or part of a plant such as scions, grafts, stock and leaves of apples, pears, peaches, plums, quince, cherry, walnut, currants, berries, rose, rosa species (including climbers), Cydonia Japonica, flowering cherry, flowering prune, and figs and willows, from one place to the other within or outside the quarantined area is prohibited. *Such plants or parts of plants shall be liable to an inspection of the same* by the District Agricultural Officer, and if found infected shall be destroyed at the owner's cost.

No such plant may leave the nursery or the place of its origin without a Health Certificate in the following form which will be issued by the Local Board or the District Agricultural Officer :—

"Issued to——address——Tehsil——District——.

Certified that the plants specified under are declared healthy and permitted to be exported to——(*Here give specification of plants, parts of plants, scions, grafts, etc.*).

(Sd.) President Local Board,

.. .. Tehsil."

(iv) that all bulbs, roots, plants, parts of plants, scions, grafts, stock with packing material should be got inspected by the District Agricultural Officer on their first entry into the Kashmir Valley with a Health Certificate from the country of their origin. If these articles are observed infected, the same will be either treated or destroyed at the owner's cost "

In this connection, it may be stated that this order has further been supplemented by a Notification under Customs Regulation where live plant material cannot cross the barrier unless accompanied with a Health Certificate from the place of export.

The live plant material exported from Kashmir mostly belongs to the Agriculture Department. There are no private nurseries, because of the network of Government nurseries, throughout the fruit producing districts. Private individuals export ornamental plants, roots, bulbs, etc., from Kashmir, but in all cases, the live plant material is not permitted to leave the Customs barrier unless it is fumigated and accompanied by a Health Certificate.

Regarding the import of live plant material, it was observed last winter that several orchardists in the Jummu Province imported grafts of peaches, apricots, citrus, mangoes, plums, roses, and other plants from private nurserymen from the Punjab and the United Provinces. None of these plants was accompanied with a

health certificate from the place of their origin. When the packages reached the Costoms Posts, these were stopped, and the importers had to experience great difficulty and inconveoience in getting the plants. The Director of Agriculture had to fumigate the plants and examine them at great inconvenience. Some rose plants had a severe infestation of live Rose Scale on them

Keeping in view the importance of the exchange of live plant material from one Provioce to another, the subject is of great importance and should be discussed in the next meeting of the Advisory Board, which would make recommendations to the Provincial Governments and suggest to them to register all private nurserymen, and keep a check on them as is done in Foreign Countries. Under this check, no private norsery could come into existence unless it undertakes to treat plant material in the field and at the time of export against insect pests and plant disease and the plants are accompanied by a Health Certificate attested by an Officer of the Provincial Agricultore Department.

This arrangement will also keep a check on the unscrupulous nurserymen who advertise what they do not actually supply later on

APPENDIX IX, N.

(Note from MR R. M. GORRIE, I.F.S., *Silvicultural Research Division, Lahore.*)

Reference item VI, crop protection, the present use of dry cut thorn branches for fencing fields is an exceedingly wasteful and improvident method besides being a factor in the destruction of neighbouring waste land, grazing grounds and government *rakhs*. *Dry thorn fences usually have to be replaced about once a year, thus forming a* constant drain upon bush and tree growth in all surrounding land.

The two plants which have been commonly used as live hedges are *Agave* (vern *keora*) and *Opuntia* or prickly pear (ver. *taur*) but the latter is not really suitable owing to its periodic destruction by disease. During [illegible] t Department has attempted to increase the local st[illegible] plants which could be spared from existing hedges [illegible] This work has been undertaken in parts of Hoshi[illegible] districts, but it is very desirable that some more comprehensive plan be undertaken for its wider distribution amongst zamindars who are prepared to use it as a live hedge. A rough survey of existing hedges which will yield stocks of plants has been started by the forest research staff and will be continued as opportunities permit. In districts already served by forest department activities, plants thus located can be dug up and collected by them and delivered wherever villagers will undertake to do the planting, but in districts where the forest department has no activities, some alternative organisation ought to take up such work.

There are two sources of obtaining *Agave* transplants. One is to dig up root suckers from existing hedges. The other is to transplant the *bulbils* or rooted buds which appear on the flower pole which each individual plant produces after an interval of some years. *Bulbils* however are not suitable for direct transplanting in new hedge sites, because they require tending and watering in a nursery for about 18 months before becoming strong enough for use as field transplants. Wherever the demand for these plants is likely to increase, it would be advisable to establish central nurseries with this object.

The *Agaves* already established in the Panjab are all capable of producing fibre similar to the sisal hemp (*Agave sisolana*), and the cultivation of the local varieties holds great possibilities for establishing a lucrative cottage industry, besides being a real improvement upon the use of dry thorn for hedging

APPENDIX X.

A press note on the visit of members of the Crops and Soils Wing of the Board of Agriculture to the Agricultural College, Research Laboratories and farms at Lyallpur (December 10th and 11th 1937).

The Crops and Soils Wing of the Board of Agriculture which met at Lahore from December 6 to 9, spent December 10 and 11 in a visit to the Punjab Agricultural College and Research Institute at Lyallpur and 45 members had an opportunity of seeing something of the work of the principal agricultural research station in the Punjab. They were shown round by Mr. H. R. Stewart, Director of Agriculture, Punjab, and members of the staff of the Institution including K B. Mohd. Afzal Husain, the Principal of the Agricultural College.

SUN AS REMEDY FOR SMUT.

On the 10th afternoon they were taken round the laboratories, the dairy and the workshop In the Botanical Section investigations on plant diseases and their control, crop physiology, seed-testing and breeding of drugs and minor economic plants were shown Some members were particularly interested in drug plants and spice crops The simple and most effective way of controlling loose smut of wheat by the solar energy method forms one of the most outstanding achievements of this Section and was found highly interesting. According to this method wheat grain is soaked in water for four hours on a bright summer day and then exposed to the sun for four hours to dry thoroughly During this treatment disease is entirely eliminated from the infected grain. The cause of gram blight due to a fungus which causes great havoc to the crop in western Punjab, its mode of perpetuation and methods of its control were exhibited Three French types of gram have been found to be resistant to the disease

VEGETABLE RENNET AND DIGESTIBILITY TRIALS

In the Chemical Section, plans of scheme of manurial experiments being carried out at different agricultural stations in the province were shown and explained in detail Cheese prepared with vegetable rennet was shown and presented to each member and the process of extracting the active enzymes from the berries of the wild plant *Withania coagulans* was explained This discovery is important in as much as certain institutions like the one at Dayal Bagh (Agra) being strict vegetarians are in search of a vegetable rennet for making cheese Trials carried out to show that leguminous and non leguminous crops were equally efficacious as green manure attracted attention Investigations on soils including reclamation of kallar and alkali soils and intensive work on certain important factors which appear continually to be at work in the Punjab soils, i e, variations in the subsoil water and the existence of what might be termed toxic layers in the soil at considerable depths were also shown. The chemical workers at Lyallpur were early in the field in the systematic investigation of the nutritive value of Indian food stuffs The work has been in progress on a small scale for the last 15 years and has been conducted with complete chemical analyses of feeding material and excreta combined with actual digestibility trials on farm animals The basic data relating to the availability of rations in the animal organism is correlated with the economic factor One of the main problems is to find the most economic and at the same time efficient rations for different purposes of animal husbandry Great interest was shown in the animal nutrition stall

FRUIT PRESERVATION

A demonstration was given of the work being done in the fruit preservation laboratory, the preparation of squashes, tomato ketchup and the canning of pears, peas, grape fruits and the making of syrups and of fruit juices This work is being financed by the Imperial Council of Agricultural Research In the fruit gardens they were shown experiments that were being conducted on various fruit juices In the bacteriological laboratory experiments with reference to the inoculation of the soil with berseem legume cultures which have proved very profitable to zamindars were seen Fish culture was also examined in the Fisheries Laboratories

PURE STRAINS OF OIL-SEEDS.

On the 11th morning the members were taken to the Risalewala farm about 5 miles from Lyallpur where they saw the work that is being done on sugarcane, cotton and multiplication of improved seeds. In the afternoon the party visited the oil-seeds section where selection is being done on the oil seed crops such as *toria* and brown *sarson* resulting in the production of selected strains which, apart from being high yielders are free from foreign admixture and yield seed of higher purity and higher oil-content than the local unselected strain To maintain the stability of these strains and to arrange for a continuous supply of freshly selected seed to the cultivators, a definite scheme of continuous mass selection and large-scale multiplication which has been put into operation was explained Besides mass-selection, other methods of group-breeding are being developed with a view to effecting further improvement in these crops In the cotton breeding area valuable work done on hybridisation, evolution of jassid-resistant varieties of cotton and pure-line selection of desi and American cottons was shown. The members were also taken to the insectary and the Students' farm A number of simple, inexpensive and highly effective physical and mechanical control measures against certain pests of important field crops and fruit trees evolved in the Entomological Section greatly interested the members. In the end a visit was paid to the dairy where rapid improvement is made in the yield of milk by proper feeding, careful selection and breeding from selected stock. Starting from the average over-all yield of 5 6 lbs. of milk per cow per day in 1914-15, in 22 years the over-all yield has gone up to 18.95 lbs. per cow per day.

The visit passed off very successfully and it was obvious that every one at Lyallpur did his very best to put up a good show. At night a dinner was given in the honour of the visit of the Board by the Principal and the staff of the Institution including guests from amongst officials stationed at Lyallpur. Speeches were made in which the members of the Board expressed their appreciation of the hard work put in by the Director and the staff at Lyallpur to make the visit a success.

PUBLICATIONS OF THE IMPERIAL COUNCIL OF AGRICULTURAL RESEARCH, INDIA

[Prices are inclusive of packing and Indian Postage]

1. Agriculture and Live-stock in India

ICAR. 1 — A bi-monthly journal of agriculture and animal husbandry for the [illegible] ...ia or the [illegible] March [illegible] scription [illegible] Volume [illegible]

2. The Indian Journal of Agricultural Science

ICAR. 5 — A bi-monthly scientific journal of agriculture and the allied sciences mainly devoted to the publication of the results of original research and field experiments. (Established 1931. Published in February, April, June, August, October and December. Prepayable subscription Rs. 15 or 24s. per annum. Price per part Rs. 3 or 5s. 3d.) Volumes I to VII complete are available.

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4. Scientific Monographs of the Imperial Council of Agricultural Research

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6. Annual Report of the Imperial Council of Agricultural Research

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